PB 204 405

THE ROLE OF PACKAGING IN SOLID WASTE MANAGEMENT 1966 TO 1976

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

BIBLIOGRAPHIC DATA SHEET	1. Report No. EPA-SW-5c-69	2.	3. Recipient's Accession No.
4. Title and Subtitle THE ROLE OF PACKAGING IN SOLID WASTE MANAGEMENT, 1966 to 1976			5. Report Date 1969
			6.
7. Author(s) Arson Darnay and William E. Franklin			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Midwest Research Institute Kansas City, Missouri 64110			10. Project/Task/Work Unit No.
			11. Contract/Grant No. PH 86-67-114
12. Sponsoring Organization Name and Address U.S. Environmental Protection Agency Office of Solid Waste Management Programs Rockville, Maryland 20852			13. Type of Report & Period Covered
			14.

15. Supplementary Notes

are discussed

Also covered are the areas

Also published as Public Health Service Publication No. 1855

16. Abstracts

Packaging materials are increasing in quantity much more rapidly than the population, primarily because of the continuing rise in self-service merchandising. Per capita consumption, which was 404 lb in 1958, is expected to be 661 lb in 1976. Until recently, no systematic analysis of the relationship between packaging and solid waste disposal had been undertaken. These interactions are defined, and the differences, with possible solutions, are explored. In ~~this three-part document, Part I discusses~~ the report packaging materials, consumption data from 1959 to 1966, and the outlook from 1966 to 1976. ~~Part II~~, concerned with disposability, analy~~zes~~ the collectability, the resistance to disposal and processing, and the salvageability and reuse of packaging materials. ~~Part III explores~~ mechanisms to mitigate problems that arise from this type of waste: how research, education, incentive programs, taxes, and regulations can reduce the quantity and reduce the processing difficulties of this disposed material, yet save the natural resources from which packages are made.

17. Key Words and Document Analysis. 17a. Descriptors

*Refuse disposal, *Packaging materials, *Salvage, *Byproducts, Incentive contracts, Taxes, Regulations, Consumption rate, Forecasts, Cans, Cartons, Drums (containers), Paperboards, Boxboard, Container board, Bag papers, Wrapping papers, Greaseproof papers, Glass, Plastics, Thermoplastic resins, Polyethylene, Metals, Aluminum, Aluminum foil, Steel alloys, Cordage

are explored

Finally the

17b. Identifiers/Open-Ended Terms

*Solid waste disposal, Sanitary landfill, Reuse, Recycling

A

17c. COSATI Field/Group 13B

18. Availability Statement Microfiche copy - NTIS Paper copy - Superintendent of Documents, Washington, D.C. 20402 (FS 2.2:So 4/8/966-76)	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 225
	20. Security Class (This Page UNCLASSIFIED	22. Price $2.25

THE ROLE OF PACKAGING IN SOLID WASTE MANAGEMENT 1966 TO 1976

PART I: The Outlook for Packaging, 1966 to 1976
PART II: The Disposability of Packaging Materials
PART III: Mechanisms for Mitigating Problems Caused by Packaging Materials in Waste Disposal

This publication (SW-5c) was written for the Bureau of Solid Waste Management by

ARSEN DARNAY and WILLIAM E. FRANKLIN
Midwest Research Institute, Kansas City, Missouri
under Contract No. PH 86-67-114

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

CONSUMER PROTECTION AND ENVIRONMENTAL HEALTH SERVICE
ENVIRONMENTAL CONTROL ADMINISTRATION
Bureau of Solid Waste Management
ROCKVILLE, MARYLAND
1969

Public Health Service Publication No. 1855

LIBRARY OF CONGRESS CATALOG CARD NO. 76-601197

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $2.25 (paper cover)

FOREWORD

Packaging and solid wastes are closely linked in public awareness. Bottles, cans, plastic and paper wrappings and cartons are all too-visible-discards around us. What the public sees as litter has been confirmed as a general solid waste problem with many facets. As pointed out in this report, 52 million tons of packaging materials were produced and used in the United States in 1966. Only 10 percent of this amount was reused or recycled back into industrial raw material channels. Ninety percent became solid wastes, accounting for over 13 percent of the Nation's total volume of solid wastes from residential, commercial, and industrial sources.

Packaging is increasing much more rapidly than population. Estimated national per capita consumption of packaging materials was 404 pounds in 1958, 525 pounds in 1966 and will be 661 pounds by 1976. Such increases are caused by several factors—self-service merchandising, ever-advancing production technology, public desire for convenience, general affluence, and the pervasive nature of packaging.

We have seen the trend toward prepared and packaged foods that lighten the housewife's kitchen chores. But packaging has also become an important part of the sales pitch. As many a woman who has bought a beautifully packaged jar of face cream can tell you, the media is the message. The 4-color-process package of baby string beans sells the box, while the set of screw drivers in the blister pack sends dad home from the hardware store with the set instead of the single tool.

To a large extent the aims of packaging and of solid waste disposal are mutually exclusive. The packager wants—and technology is developing—a container that won't burn, break, crush, degrade, or dissolve in water. The waste processor wants a package which is easy to reduce by burning, breaking, compaction, or degradation. The final objective of solid waste management is to reduce the total quantities of solid waste and unsalvageable materials through recovery and reuse. In an ideal system, packaging materials would never be discarded—they would be reprocessed by industry and made into new packages or other products.

Packaging does indeed pervade our culture. Now and for the immediate future we will have to deal with the discarded portions of 52 million and more annual tons of these materials. The present report is, we feel, a significant exploration of the nature of this problem.

—Richard D. Vaughan, *Director,*
Bureau of Solid Waste Management.

SUMMARY

This document presents the findings of a research effort to define the role of packaging in waste disposal in the 1966 to 1976 period. The report is divided into three parts:

- *Part I* presents historical packaging material consumption data for the 1958 to 1966 period, a forecast of packaging material consumption to 1976, and a discussion of the economic, technological, marketing, and demographic trends and forces underlying the forecast.

- *Part II* analyzes the disposability of packaging materials in 1966 and in 1976. The quantitative solid waste burden imposed by packaging in the two years is discussed, as well as collection problems engendered by packaging, and packaging material resistance to disposal processing.
- *Part III* is an exploratory analysis of the various mechanisms that might be employed for mitigating the problems caused by packaging materials in waste disposal.

These above sections are followed by two appendices. Appendix I presents tabular materials that will permit interested persons to follow the route by which we arrived at our Disposal Resistance Index figures. Appendix II is a bibliography of literature used as background for this analysis.

All tabular and graphic materials are numbered consecutively throughout the report, as are all reference citations. The references cited are found listed at the end of the report in the section preceding the appendices.

Part I

In 1966, 51.7 million tons of packaging materials were produced and sold in the United States. Of this massive tonnage—made up of many billions of individual units, most of them weighing much less than a pound each—about 90 percent entered the stream of solid wastes that had to be disposed of, thus accounting for about 13 percent of the 350 million tons (9.7 pounds per person per day) of residential, commercial, and portions of industrial wastes generated.*

The 1966 tonnage was well above 1958 packaging materials consumption. In 1958, 35.4 million tons were consumed in the United States. And in 1976, consumption of packaging materials across the nation should have increased to 73.5 million tons, up 21.8 million tons from 1966.

Packaging is increasing in quantity much more rapidly than population. Per capita consumption of packaging materials was 404 pounds in 1958, 525 pounds in 1966, and will be 661 pounds by 1976.

Many factors underlie this dramatic increase, but chief among them is the continuing rise of self-service merchandising, creating a growing need for packages that sell the product without the help of a sales clerk. This accounts for much of the quantitative increase.

Qualitative changes will be brought about by the need for improved product differentiation by packaging methods (another result of self-service merchandising requirements), the rise of many new food products which call for unique packaging solutions (instant foods, freeze-dried foods, etc.), and the vastly expanded choice in materials provided the package designer by the advent of plastics and other relatively new packaging materials.

In spite of these forces, the relative importance of the basic packaging materials—paper, glass, metals, wood, plastics, and textiles—will remain about the same throughout the 1966 to 1976 period. Paper and paperboard which accounted for 54.8 percent of all packaging by weight in 1966, will represent 56.9 percent of packaging in 1976. Metals and glass will also maintain their proportions of the market. Both wood and textiles will decline somewhat. Only in plastics packaging materials will there be a dramatic change: plastics, which held 2.4 percent of the packaging market by weight in 1966, will have doubled their share by 1976.

---

* Excludes agricultural wastes (1.3 billion tons a year), mining wastes (1 billion tons per year), scrapped automobiles (5 million units or about 15 million tons per year), and building rubble, for which we have no estimates.

Part II

Of packaging materials consumed in 1966, approximately 46.5 million tons were discarded as waste; the remaining 10 percent was returned for reuse or reprocessed into new products.

Collection and disposal of this tonnage cost the nation $419 million in 1966. Assuming no increase in the costs of collection and disposal, which is unlikely, expenditures on the disposal processing of packaging materials will stand at $595 million in 1976, up by $176 million. In that year, 66.2 million tons of packaging will have to be handled as waste.

Collection of the *increase* alone, some 19.7 million tons, will require nearly 5 million collection trips in 1976; trips that did not have to be made in 1966, and which will call for the addition of some 9,500 new collection vehicles at a cost ranging between $135 and $190 million.

Collection will be more difficult for several reasons: a dramatic increase in one-way beverage containers is expected to intensify the litter problem; the uncompacted density of packaging material wastes will decrease because lighter and more resilient materials will have gained a proportionately larger share of packaging markets (measured in weight); and compactibility of packaging wastes will have deteriorated slightly.

To measure the difficulty of processing packaging wastes in the five basic disposal and/or reduction processes, a rating system was developed by MRI to establish the relative resistance of various packaging materials and package configurations to the requirements of processes. Resistance was measured on a scale from 100 (indicating no resistance) to 500 (indicating complete unsuitability of the material for the process). Overall, packaging materials received a rating of 132 in the year 1966 and 148 in the year 1976, indicating that processing will be considerably more difficult in 1976 than it was 10 years earlier.

By far the greatest impact on the resistance measure will be brought about by changes in the type of process used for waste disposal. The increasing percentage of material handled by sanitary landfilling and incineration will account for 94 percent of the increase in the resistance index value. Changes in the relative dominance of materials and package configurations will account for the remaining 6 percent of the increase.

Considerable space is devoted in this part of the report to the salvage and reuse of packaging materials. The findings indicate that packaging materials play an extremely small part in the secondary materials industry. With the exception of corrugated paperboard, of which about 20 percent is reused, and minute quantities of steel and aluminum cans, most other packaging materials never enter reuse channels. The salvage industries in general are poorly equipped technologically to handle heterogeneous material mixtures and the increasing number of material combinations which packaging presents. Secondary materials are not sought extensively by raw materials processors because virgin resources are frequently cheaper to process. Prices of secondary materials are often too low for profitable salvage operations. Without external intervention, salvage will continue to decline in importance.

Part III

In this part of the report, five types of mechanisms are discussed as possible avenues to the mitigation of problems created by packaging materials in waste disposal: (1) research and development, (2) educational efforts, (3) incentive and subsidy programs, (4) taxes, and (5) regulation. These mechanisms are evaluated as possible means to:

- Reduce the quantity of packaging materials used
- Reduce the technical difficulty involved in processing packaging wastes
- Reduce the destruction of valuable natural resources from which packages are made

Research and Development (R&D)

This mechanism would be applicable to the reduction of difficulty in processing waste packages and in promoting reuse and recycle of packaging materials. Three types of R&D are possible: research on materials and containers, R&D devoted to improving salvage and reuse, and efforts aimed at improving disposal technology. The last item is beyond the scope of this investigation but appears to be an area of considerable potential. Materials research does not offer foreseeable near-term success. Research to improve the technology of salvage, particularly development of materials separation techniques, is cited as the most promising activity of those discussed.

Educational Efforts

Educational programs directed at three groups are discussed—industry programs, consumer education, and intra-government information programs. Basic to all of these is the assumption that one of the constraints to action on the part of all those involved is unfamiliarity with the problems created by packaging. Once the problems are fully understood, voluntary action to mitigate the problems may be forthcoming.

Incentives and Subsidies

Incentive type programs would be effective in reducing the technical difficulty of processing wastes and in improving salvage. Use of the government's purchasing power would be one means of accomplishing the first aim; subsidy of salvage operations by price supports of secondary materials and by support of suitable technology by tax credit or direct funding programs would accomplish the second.

Taxes

Two types of taxes are discussed: a use tax, imposed on all packages, and a deterrent type tax, selectively imposed on specific materials. A packaging use tax would not directly result in reduction of package material use, reduction of processing difficulty, or in elimination of destruction of natural resources. It would, however, create the economic wherewithal for the processing of these wastes. Justification of a use tax would be easier than justification of a deterrent tax. For maximum effectiveness, however, a packaging use tax would call for extensive administrative machinery.

A deterrent type tax would be difficult to justify and would be limited in effectiveness. Regulatory action would be the more effective mechanism for curbing the use of a material or container type deemed unacceptable from the waste disposal standpoint.

c

Regulation

Regulation of packaging would be the most effective mechanism to accomplish the objectives. It would be difficult to justify such activity, however, because the problems created by packaging materials are primarily economic problems. Given the tremendously complex nature of packaging, regulation, to be effective, would tend to embrace all activities directly and indirectly concerned with packaging. The costs of such a program appear to be potentially greater than the benefits that may be expected.

PREFACE

This report on the role of packaging in solid waste, for the period of 1966 to 1976 was prepared by Midwest Research Institute pursuant to Contract No. PH 86-67-114, with the Public Health Service, U.S. Department of Health, Education, and Welfare. The statements, findings, conclusions, recommendations, and other data in this report do not necessarily reflect the views of the Department of Health, Education, and Welfare.

Principal investigators were Mr. Arsen Darnay (project manager) and Mr. William E. Franklin. Valuable staff support was provided to the investigators by Dr. T. D. Bath, Mrs. Margaret Cossette, Mr. R. E. Gustafson, Mr. J. B. Maillie, Mr. J. H. Stierna, and Dr. A. E. Vandegrift. Mr. John McKelvey, Assistant Director, Economic Development Division, had responsibility for general supervision of the project.

Many individuals and organizations provided information, advice, commentary, and suggestions to the research team. We should like to express our thanks and appreciation to all those who collaborated in this enterprise.

ACKNOWLEDGEMENTS

A study effort encompassing an entire industry, especially one as diverse and dynamic as packaging, could not have been accomplished without the active participation and assistance of many companies, associations, independent researchers, and government agencies. The cooperation and help given to the research team by all these organizations has been outstanding and far surpassed the norm common in research. We are pleased to acknowledge our indebtedness to all for the value of this report, while retaining full responsibility for errors or omissions.

Space does not permit a complete listing of all participating organizations, but we should like to acknowledge a special debt to the following:

COMPANIES

American Can Company
100 Park Avenue
New York, New York 10017

The Bassichis Company
2323 West 3rd Street
Cleveland, Ohio 44113

Bettendorf Publications, Inc.
228 North LaSalle Street
Chicago, Illinois 60601

Container Corporation of America
38 South Dearborn
Chicago, Illinois 60603

Continental Can Company
633 Third Avenue
New York, New York 10017

E. I. du Pont de Nemours Company
9519 Nemours Building
Wilmington, Delaware 19801

PACKAGING

Modern Packaging Magazine
1301 Avenue of the Americas
New York, New York 10019

National Can Corporation
5959 South Cicero
Chicago, Illinois 60638

New Jersey Cullet Supply Corporation
Pier K
Jersey City, New Jersey 07303

Owens-Illinois Technical Center
1700 North Westwood Avenue
Toledo, Ohio 43607

Reynolds Metals Company
6601 West Broad Street
Richmond, Virginia 23218

Union Camp Corporation
233 Broadway
New York, New York 10007

U.S. Reduction Company
4610 Melville Avenue
East Chicago, Indiana 46312

Weyerhauser Company
Paperboard Packaging Division
100 South Wacker Drive
Chicago, Illinois 60606

INDUSTRY ASSOCIATIONS

Adhesives Manufacturers Association of America
441 Lexington Avenue
New York, New York 10017

The Aluminum Association
420 Lexington Avenue
New York, New York 10017

Aluminum Foil Container Manufacturers Association
P.O. Box D
Fontana, Wisconsin 53125

American Paper Institute
216 Madison Avenue
New York, New York 10017

American Paper Institute
Paperboard Group
80 East Jackson Boulevard
Chicago, Illinois 60604

American Public Works Association
1313 East 60th Street
Chicago, Illinois 60637

The Associated Cooperage Industries of America, Inc.
808 Olive Street
St. Louis, Missouri 63101

Bulk Packaging and Containerization Institute
P.O. Box 3444
Grand Central Station
New York, New York 10017

Can Manufacturers Institute, Inc.
821 15th Street, N.W.
Washington, D.C. 20005

Chemical Specialties Manufacturers Association
50 East 41st Street
New York, New York 10017

Fibre Box Association
224 South Michigan Avenue
Chicago, Illinois 60604

Folding Paper Box Association of America
222 West Adams
Chicago, Illinois 60606

Glass Container Manufacturers Institute
330 Madison Avenue
New York, New York 10017

Glass Container Manufacturers Institute
Research Division
1405 South Harrison
East Lansing, Michigan 48823

National Barrel and Drum Association, Inc.
1028 Connecticut Avenue, N.W.
Washington, D.C. 20006

National Committee for Paper Stock Conservation
80 East Jackson Boulevard
Chicago, Illinois 60604

National Council of Refuse Disposal Trade Associations
330 South Wells
Chicago, Illinois 60606

National Fiber Can and Tube Association
1725 Eye Street, N.W.
Washington, D.C. 20006

National Flexible Packaging Association
11750 Shaker Boulevard
Cleveland, Ohio 44120

National Paper Box Manufacturers Association, Inc.
Suite 910
City Center Building
121 North Broad Street
Philadelphia, Pennsylvania 19107

National Refuse Sack Council, Inc.
60 East 42nd Street
New York, New York 10017

National Wooden Pallet and Container Association
1619 Massachusetts Avenue, N.W.
Washington, D.C. 20036

Packaging Institute
342 Madison Avenue
New York, New York 10017

Paperboard Packaging Council
1250 Connecticut Avenue, N.W.
Washington, D.C. 20036

Society of the Plastics Industry
250 Park Avenue
New York, New York 10017

Steel Shipping Container Institute, Inc.
600 Fifth Avenue
New York, New York 10020

Textile Bag Manufacturers Association
518 Davis Street
Suite 208
Evanston, Illlnois 60201

Western Wooden Box Association
55 New Montgomery Street
San Francisco, California 94105

Wirebound Box Manufacturers Association, Inc.
222 West Adams Street
Chicago, Illinois 60606

GOVERNMENT AGENCIES

Chicago Sanitation Department
54 West Hubbard
Chicago, Illinois 60610

Congressman William F. Ryan
Cannon Office Building
Washington, D.C. 20012

New York City Department of Sanitation
125 Worth Street
New York, New York 10013

U.S. Department of Commerce
Business and Defense Services Administration
Containers and Packaging Division
Main Commerce Building
14th and Constitution Avenues
Washington, D.C. 20002

CONTENTS

Part I—The Outlook for Packaging, 1966 to 1976

Page

Introduction 3
Methodology 3
  Approach 3
  Data Sources—Statistical and General 4
  General Background and Assumptions 5
An Overview of Packaging 5
  Role in the Economy 5
  Role in Solid Waste 5
  Services Performed 5
  Technological Base 6
  Markets 7
  Supplying Industries 7
    Paper and Paperboard 8
    Metals 10
    Glass 11
    Plastics 11
    Wood 11
Basic Trends in Packaging 11
  More Packaging Consumption per Capita 12
  Increasing Number of Package Types 12
  More Complex Packages 14
Paper and Paperboard 15
  Paperboard 16
    Containerboard 16
    Boxboard 20
    Paperboard—Summary Outlook 24
  Flexible Paper 26
    Bag Paper 26
    Converting Paper 27
    Wrapping Paper 27
    Shipping Sacks 28
    Glassine, Greaseproof, and Vegetable Paper 29
    Flexible Papers—Summary Outlook 29
  Specialty Paper 31
    Coated Converting Paper (One Side) 31
    Uncoated Converting Paper (Book Paper) 31
    Tissue Paper 31
    Molded Pulp 31
    Specialty Paper—Summary Outlook 32

Page
Glass 32
  Technological Trends 34
  Competitive Trends 35
  Outlook for Non-beverage Glass Containers 36
    Food 36
    Drugs and Cosmetics 36
    Chemicals 36
  Outlook for Glass Beverage Containers 36
  Glass: Summary Outlook 43
Metals 43
  Metal Cans 47
    Aluminum 47
    Trends in Steel 55
    Aerosol Containers 55
    Competing Materials 57
    Metal Cans: Summary Outlook 57
  Aluminum Foil 57
    Semi-Rigid Aluminum Foil Containers 57
    Nonrigid Aluminum Foil 60
  Collapsible Metal Tubes 62
  Steel Drums and Pails 64
  Metal Strapping 66
  Gas Cylinders 66
  Metal Caps and Crowns 66
    Metal Caps 66
    Metal Crowns 67
Plastics 67
  Description of Plastics 68
  Uses 69
  General Trends 69
  Flexible Plastics Packaging 70
    Flexible Packaging 70
    Shrink Packaging 75
    Polyethylene Films 76
    Other Plastic Films 76
    Cellophane 77
  Molded Plastic Containers 78
    Formed Containers 78
    Plastic Foams 81
    Plastic Bottles 82
    Plastic Clousures 87
    Plastic Tubes 87
Wood 87
  Nailed Wooden Boxes 88
  Wirebound Boxes 90
  Slack and Tight Cooperage 90
  Wood Veneer 91
Textiles 91

Page
Miscellaneous Packaging Materials.......... 92
  Pallets and Skids.......... 93
  Cushioning Materials.......... 93
    Shredded Paper for Packing.......... 93
    Excelsior.......... 95
  Connective Component Materials.......... 95
    Tag Stock.......... 95
    Tapes.......... 95
    Cordage and Twine.......... 95
  Coatings and Other Applied Materials.......... 96
    Adhesives.......... 96
    Wax.......... 96
    Polyethylene Coatings.......... 96
    Other Plastic Coatings.......... 97
    Inks.......... 98
Summary.......... 99

Part II—The Disposability of Packaging Materials

Introduction.......... 109
Discussion of Disposability.......... 109
Analysis of Quantitative Changes.......... 110
  Packaging Waste in Perspective.......... 110
  Absolute and Relative Increases.......... 113
  Significance of Findings.......... 116
Analysis of Collectibility.......... 116
  Collection in Perspective.......... 116
  Some Basic Distinctions.......... 116
  Litter.......... 117
  Volume.......... 118
  Other Factors Affecting Collectibility.......... 118
  Significance of Findings in Collection.......... 119
Analysis of Resistance to Disposal.......... 119
  Disposal Methods in Perspective.......... 119
  Discussion of Processes and Materials.......... 121
    Incineration.......... 121
    Sanitary Landfilling.......... 123
    Open Dumping.......... 124
    Composting.......... 125
    Salvage, Reuse, and Conversion.......... 126
Analysis of Resistance to Processing.......... 133
  Approach to the Analysis.......... 133
  How Resistance Values Were Assigned.......... 133
  How the Index Was Calculated.......... 136
    Step 1: Rating.......... 136
    Step 2: Consolidation.......... 136
    Step 3: Weighting by Market Share Within Categories.......... 136
    Step 4: Calculation of the Index.......... 138
    Limitations and Future Opportunities.......... 139
    Analysis of Findings, 1966–1976.......... 139
    Ranking of Materials and Processes.......... 141
    Comparative Resistance Values of Nine Disposal Process Cases... 142

Part III—Mechanisms for Mitigating Problems Caused by Packaging Materials in Waste Disposal

Page

- Introduction 147
  - Formulation of Objectives 147
- Mechanisms for Achieving Objectives 148
  - Reduction of the Quantity of Packaging Wastes Generated 148
  - Conservation of Natural Resources 148
  - Reduction of the Technical Difficulty of Handling Packaging Wastes in Disposal Facilities 148
- Evaluation of Mechanisms 149
  - Research and Development 149
    - Materials Research 149
    - Salvage Technology Research 150
  - Educational Efforts 151
    - Industry Programs 151
    - Consumer Programs 152
    - Intra-Government Information Programs 153
  - Incentives and Subsidies 154
    - The Question of Justification 154
    - Incentives and Salvage 154
    - Government Purchasing Policy as an Incentive 156
  - Taxes 157
    - The Concept of Packaging Use Tax 157
    - A Deterrent Tax 158
  - Regulation 160
    - The Nature of Current Regulatory Activity 160
    - Regulation in Packaging 161
    - Case 1: Regulation of Quantity 163
    - Case 2: Regulation of Materials 164
    - Case 3: Regulation of Container Types 165
    - Summary 166
- Barriers to Action 166
  - General 166
  - Techno-Economic Barriers 167
  - Socioeconomic Barriers 168
  - Cultural Barriers 169
  - Demographic Barriers 169
  - Recommendations 170

- References 171

- Appendix I—The Disposability of Packaging Materials 173
- Appendix II—Bibliography 189

LIST OF TABULAR MATERIAL

Part I—The Outlook for Packaging, 1966 to 1976

Table ... Page

1 Distribution of Packaging Output by Selected End Use: 1958–1963 ... 7
2 Distribution of Packaging Outputs to Selected Consumer Packaging End-Use Markets: 1958–1963 ... 8
3 Distribution of Packaging Output to Selected Consumer Packaging End-Use Markets: 1958–1963 ... 8
4 Production of Selected Groups of Paper and Paperboard: 1966 and 1976. 16
5 Production of Paperboard: 1958 to 1966 ... 17
6 Consumption of Paperboard Packages by Type: 1958 to 1966 ... 17
7 Containerboard Types: Description and Relative Importance: 1966 ... 17
8 Distribution of Corrugated and Solid Fiber Shipping Containers to End-Use Markets: 1958–1966 ... 18
9 Boxboard Production: 1958–1966 ... 20
10 Distribution of Set-Up Paper Boxes to End-Use Markets: 1958 to 1966. 21
11 Distribution of Folding Paper Boxes to End-Use Markets: 1958 to 1966. 21
12 Special Foodboard Production by End Use: 1958 to 1966 ... 22
13 Distribution of Fiber Can and Tube Shipments: 1965 and 1966 ... 23
14 Fiber Drum Shipments by End Use: 1966 ... 23
15 Fiber Drum Shipments 1958 to 1966 ... 24
16 Production of Paperboard Materials by Type: 1966 and 1976 ... 26
17 Production of Converting Paper by Type: 1958 to 1966 ... 28
18 Production of Flexible Paper by Type: 1966 and 1976 ... 29
19 Tissue Paper Production by End Use: 1958 to 1965 ... 32
20 Production of Specialty Paper by Type: 1966 and 1976 ... 32
21 Typical 1967 Prices of Glass and Plastic Bottles for Toiletries and Cosmetics ... 36
22 Milk Container Consumption and Milk Glass Container Fillings: 1958 to 1966 ... 36
23 Shipments of Glass Containers by End Use: 1955 to 1976 ... 37
24 Distribution of Glass Container Shipments by End Use: 1958 to 1976. 40
25 Beer and Soft Drink Container Production by Type of Container and Use: 1958, 1966, and 1976 ... 41
26 Shipments of Beer and Soft Drink Containers: 1958 to 1976 ... 44
27 Consumption of Metal Packaging Materials by Type: 1966 and 1976. 45
28 Consumption of Metal Cans by End Use: 1958, 1966, and 1976 ... 47
29 Shipments of Metal Cans by End Use: 1958 to 1976 ... 50
30 Number of Cans Consumed by End Use: 1958 to 1967 ... 51
31 Nonfood Aerosol Containers Consumed by Size: 1955 to 1966 ... 56
32 Consumption of Aerosol Containers by End Use: 1958 to 1966 ... 58
33 Aluminum Consumed in Packaging ... 60
34 Consumption of Aluminim Foil by End Use: 1958 to 1965, in millions of pounds ... 61
35 Consumption of Aluminum Foil by End Use: 1958 to 1965, in percent of total pounds ... 62
36 Shipments of Collapsible Tubes by End Use: 1958 to 1966, in millions of units ... 63
37 Shipments of Collapsible Tubes by End Use: 1958 to 1966, in percent of shipment ... 63

Table		Page
38	Shipments of Collapsible Tubes by Type of Metal: 1958 to 1966	63
39	Shipments of Steel Shipping Barrels, Drums, and Pails: 1958 to 1966	65
40	Shipments of Steel Barrels, Drums, and Pails by End Use: 1958–1966	65
41	Shipments of Closures for Containers: 1958–1966	67
42	Consumption of Plastics by End Use: 1958 to 1976	68
43	Plastics Consumed in Packaging by Type of Material: 1966	70
44	Plastics Consumed in Packaging: 1965–1967	71
45	Consumption of Film in Packaging: 1966 and 1976	73
46	Films Consumed in Packaging by Type: 1958 to 1966	73
47	Film Consumed in Shrink Packaging: 1963–1966	75
48	Polyethylene Film Consumed in Packaging by End Use: 1961–1966	76
49	Shipments of Cellophane by End Use: 1962–1966	77
50	Representative 1967 Prices of Selected Packaging Papers, Films, and Foils	77
51	Consumption of Formed and Molded Plastics by Type: 1966 and 1976	78
52	Resins for Bottles—Comparative Data	84
53	Shipments of Blow-Molded Plastic Bottles by End Use and Resin: 1960 to 1976	85
54	Consumption of Wood in Packaging by End Use: 1966 and 1976	88
55	Shipments of Wooden Containers by Type: 1958–1976	88
56	Shipments of Textiles for Packaging: 1958–1976	92
57	Shipments of Textile Bags by End Use: 1958–1966	92
58	Consumption of Cushioning and Component Material by Type, 1966 and 1976	93
59	Consumption of Miscellaneous Packaging Materials: 1958–1976	94
60	Consumption of Polyethylene Extrusion Coatings: 1962, 1964, and 1966	97
61	Plastic Coatings Consumed in Packaging by Type of Plastic: 1965 and 1966	98
62	Total Packaging Consumption by Type of Material: 1966–1976	98
63	Consumption of Packaging Materials by Type: 1958–1976	101
64	Consumption of Packaging Materials by Type: 1958–1976	102
65	Consumption of Packaging Materials by Kind: 1958–1976	104
66	Per Capita Consumption of Packaging Materials by Kind: 1958–1976	105

Part II—The Disposability of Packaging Materials

Table		Page
67	Average Annual Increase in Per Capita Consumption of Packaging Materials: 1958 to 1976	116
68	Increase in Per Capita Consumption of Packaging Materials: 1966 to 1976	116
69	Survey of Litter Found Along a One-Mile Stretch of Two-Lane Highway in the State of Kansas	117
70	Per Capita Consumption of Beverage Containers: 1966 and 1976	117
71	Composition of a Ton of Packaging Materials: 1966 and 1976	118
72	Shipments of Metal Cans by End-Use Markets: 1965	119
73	Relative Dominance of Disposal Methods: 1966 to 1976	120
74	Inert Residue of a Ton of Packaging Materials by Material: 1966 and 1976	121
75	Heating Values of Packaging Materials: 1966	122

Table Page
76 Sulfur Content of a Ton of Representative Packaging Materials: 1966 .. 122
77 Density of Solid Packaging Materials 123
78 Consumption of Fibrous Materials in Paper and Board Mills 129
79 Selected Paperstock Price Ranges: 1966 to 1967 130
80 Number of Glass Containers Required To Make One Ton of Cullet ... 131
81 Suitable Material Characteristics 133
82 Rating Definitions of Incineration 135
83 Rating Definitions of Sanitary Landfill 135
84 Rating Definitions of Composting 135
85 Rating Definitions of Salvage, Reuse, and Conversion 136
86 Disposability Ratings: Metals 137
87 Disposability Resistance Calculation: Metals, 1966 138
88 Disposability Resistance Values of Major Material Groupings by Disposal Process: 1966 138
89 Calculation of Disposability Resistance Index: 1966 140
90 Effect of Disposal Process on Disposability Resistance Index by Material: 1966 and 1976 141
91 Effect of Materials on Disposability Resistance Index by Disposal Process: 1966 and 1976 141
92 Comparison of Packaging Materials and Their Contribution to Volume and Resistance: 1966 and 1976 142
93 Disposability Processes and Their Contribution to Materials Handled and Resistance: 1966 and 1976 142
94 Influence of Disposal Process Share on the Disposability Resistance Index: 1976 143

Part III—Mechanisms for Mitigating Problems Caused by Packaging Materials in Waste Disposal

95 Estimated Annual Cost of Operating a Waste Disposal Technology Information Center 154
96 Major Federal Government Departments and Agencies With Regulatory Functions and Principal Justifications for Their Activities ... 161
97 Federal Packaging Regulations and the Agencies That Enforce Them .. 162
98 Package Costs of Selected Products 164
99 1967 Container-Litter Legislative Bills Introduced 165
100 Importance of Barriers to Waste Reduction Objectives 167
101 Index of Disposable Personal Income and Per Capita Personal Consumption Expenditures on Selected Items 169
102 Estimates of Average Work Week and Length of Vacation Per Year by Major Occupational Groups: 1960 and 1976 170

Appendix I

103 Calculation of Disposal Resistance Index: 1976 175
104 Disposability Ratings: Paper and Paperboard 176
105 Disposability Resistance Calculations: Paper and Paperboard, 1966 .. 177
106 Disposability Resistance Calculations: Paper and Paperboard, 1976 .. 177
107 Disposability Ratings: Metals 178
108 Disposability Resistance Calculation: Metals, 1966 179
109 Disposability Resistance Calculation: Metals, 1976 179

Table		Page
110	Disposability Ratings: Glass	180
111	Disposability Resistance Calculation: Glass, 1966	181
112	Disposability Resistance Calculation: Glass, 1976	181
113	Disposability Ratings: Wood	182
114	Resistance Calculation: Wood, 1966	183
115	Disposability Resistance Calculation: Wood, 1976	183
116	Disposability Ratings: Plastics	184
117	Disposability Resistance Calculation: Plastics, 1966	185
118	Disposability Resistance Calculation: Plastics, 1976	185
119	Disposability Ratings: Textiles	186
120	Disposability Resistance Calculation: Textiles, 1966 and 1976	187

PART I

The Outlook for Packaging, 1966 to 1976

The Outlook for Packaging, 1966 to 1976

INTRODUCTION

In Part I of this report, the outlook for packaging materials in the 1966 to 1976 period is discussed. Analysis of the disposability of packaging materials is reserved for Part II, and discussion of various actions which may be taken to mitigate the solid waste problems arising from packaging materials is taken up in Part III.

A general description of the methodology is presented first. Next a general overview of packaging is presented, followed by an analysis of general trends affecting the future of packaging as a whole. Thereafter, separate sections are devoted to each basic packaging material category. Finally, the forecasts are summarized in the concluding section of this analysis.

METHODOLOGY

In this section, some overall observations are made about the methods used to arrive at forecasts in Part I of the report. Considering the breadth of the analysis and the multitude of individual material and configurational categories that were treated, the following discussion is perforce general in nature; it is impractical to trace the method by which each specific packaging material or configurational grouping was forecast.

Approach

The general methodological approach to this study involved the acquisition and evaluation of both quantitative and qualitative inputs about packaging on which judgments about the most likely developments in packaging could be made. Separate forecasts were prepared for each packaging material and configurational category. These forecasts were then reconciled with one another and tallied to obtain an overall prediction of 1976 packaging materials consumption.

Packaging materials were first identified, and consumption data for the 1958 to 1966 period were gathered in as much detail as possible. Statistical data served as a starting point for forecasts. Units of measure (dollar sales, units such as gross, base boxes, square feet, tons, etc.) were converted into pounds to establish a comparable quantitative base in a unit of measure which would have the most meaning from a solid waste processing standpoint. Such an approach is unique; in most packaging studies, the most common uniform measure used is value of shipments expressed in dollars.

Since many types of packaging applications depend on broad economic and socioeconomic movements (food consumption, for instance, follows population growth and disposable income trends), historical trends were examined with care. The initial forecasts of 1976 consumption, for instance, were based on the 1958 to 1966 rate of change within material and configurational categories, their growth or decline, whichever applied. Few of these initial forecasts were allowed to stand. Most were modified, some drastically, on the basis of qualitative analysis of trends in technology, marketing, cost, and other factors. As part of this study, extensive correlation analysis (regression analysis) was undertaken to determine if packaging material consumption could be correlated positively with various economic and demographic indicators (for instance, grocery store sales, expenditures on recreation, number of working wives in the labor force, etc.). Altogether, the correlation between each of 42 indicators and each of 47 packaging categories was measured, using computer techniques. No significant correlations were discovered, however, probably because the eight data points used (1958 to 1966) were too few.

Much effort in the research was devoted to identification of trends in technology and evaluation of significant developments taking place or likely to take place in the future. Two types of developments received attention: *internal* changes in packaging that center primarily on intermaterials competition, new materials and config-

Preceding page blank

urations, changing cost structures, and changing market conditions; and *external* environmental changes in packaging requirements arising from social, economic, marketing, governmental, and technological factors.

Four basic questions were asked about specific packaging developments: How probable is it that the development will actually materialize considering such factors as its technical feasibility, economics, and prevailing and expected market conditions? What would be the qualitative effects of the development on the quality, quantity, production and conversion technology, and marketing of packaging? What would be the quantitative effect of the development? What would be the time-rate relations of the change?

Packaging technology was evaluated with a view to several specific factors. Among these were: the consumption trends and container requirements of the products to be packaged; methods of distribution to the consumer; packaging material/product performance requirements; packaging material functional characteristics and costs; production and conversion machinery technology and costs; and inter-materials competition. Assessment of these important factors as they relate to each packaging material or packaging-related development led to judgments about whether or not all these factors working in combination were likely to produce a significant new packaging application in terms of quantity and what the effects would be on competing materials and configurations.

Throughout the analysis of packaging and packaging materials, emphasis was placed on identifying those forces—technological, sociological, economic, or marketing—that will have the greatest impact in the next 10 years. Particular stress was placed on factors that will have the greatest influence on solid waste. Therefore, the forecasts were expressed in terms of two general criteria: (1) the materials technology and its result on product quality and physical characteristics; (2) the quantity of each material that will be consumed in 1976.

During the preparation of forecasts, quantitative projections in three modes were developed: highest possible consumption, most likely consumption, and lowest possible consumption. In this report, we have consistently selected what we considered the "most likely" future consumption rates.

Data Sources—Statistical and General

Statistical data were derived primarily from government, trade association, and trade publications. The most important government sources were the Business and Defense Services Administration's *Containers and Packaging*, and various Current Industrial Reports series. Many trade associations also provided good statistical information. Among these were the American Paper Institute, Inc., the Can Manufacturers Institute, Inc. and the Glass Container Manufacturers Institute, Inc. The primary trade publications were *Modern Packaging*, *Modern Plastics*, and *Paperboard Packaging*.

Midwest Research Institute (MRI) provided additional data, conversion factors, and estimates for the categories in which data were not available or required modification.

The statistical data are considered to be reasonably accurate; for the most part they are based on expert estimates or direct reporting. Rough estimates had to be used only for relatively minor material categories. Where conversion factors were used, the data were based on a test sample or industry estimates.

In the forecasts, the consumption figures were derived by using the basic unit of measure for that material (e.g., base boxes for steel cans) and converting it to pounds based on the forecast materials technology and types.

The extensive literature on packaging provided one base for the qualitative analysis. In addition, MRI had extensive contact through field visits, telephone interviews, and visits at MRI offices with industry officials in trade associations and packaging companies to verify the qualitative judgments that were made. However, the final forecasts are MRI's and they do not necessarily agree with those of persons we interviewed.

There are, of course, limitations to a 10-year forecast. For example, research in private laboratories may already have produced new packaging developments that could have significant effects but are guarded secrets of the trade today. Indirect evaluation of the probability of such developments was part of this analysis, however. Many of the forecasts rest upon a multitude of variables—cost, material technology, market acceptance, etc.—and any changes in these variable conditions could change a forecast appreciably. However, these factors are usually subject to continuing surveillance and in some cases were specifically pointed out in this report. Broad movements are generally well established and variations in future packaging will most likely show up in specific applications rather than in whole new major configurations or materials types.

General Background and Assumptions

As in most studies of this type, assumptions were made about general environmental conditions for background purposes. For example, it was assumed that the U.S. economy would continue to show the relatively stable conditions experienced in the last 10 years and that serious dislocation would not occur. The general growth of the Gross National Product and output of goods was based on accepted government forecasts of about 4 percent per year real growth. Population growth was assumed to be at a slower rate than in previous years, and the second lowest rate of growth published by the Bureau of Census was used. In addition to assumptions about the general environment, the Midwest Research Institute forecasts were also based on certain assumptions about the forces at work in packaging today and the most likely conditions a decade hence. Specifically, no adjustments were made for the impact on packaging of Federal or local programs aimed at easing the solid waste or litter burden created by packaging; any such programs initiated before 1976 may have considerable influence on packaging material consumption.

AN OVERVIEW OF PACKAGING

Role in the Economy

Packaging is a service activity intrinsically connected with the mass distribution of goods in the U.S. marketplace. Wherever commodities are sold, packaging can be found; as a consequence, this service activity touches virtually all aspects of the nation's economic life. With the exception of fuels which are pipelined directly to the user or moved in special conveyances to the site of use in bulk form, those building materials which are conveyed in unpackaged form to the construction site, automobiles and certain other wheeled equipment, and a few commodities which are delivered to the consumer directly, like newspapers, everything is packaged in one form or another before reaching the consumer. The package may be a pallet on which the product is held in place, a drum, a sack, a corrugated box, or one of the many other consumer packaging configurations.

Not surprisingly, a substantial percentage of the nation's expenditures goes for items whose primary purpose is to convey products to market and which are not desired for their own sake. In 1966, the public, commercial organizations, and industry spent in excess of $25 billion on packaging in all of its aspects—approximately 3.4 percent of Gross National Product. Of the total, $16.2 billion were spent on packaging materials, $225 million on machinery to shape and process the materials, and the remaining $9 billion represented value added to the materials by the package manufacturer.

Role in Solid Waste

Since packaging materials are used primarily to convey goods from manufacturer to user, and since most packages make only a single trip after which they are discarded, packaging plays an important role as a component of solid waste.

The $16.2 billion worth of materials purchased in 1966 weighed 51.7 million tons. About 90 percent of these materials was discarded, representing 13.3 percent of the 350 million tons of residential, commercial, and industrial waste generated in the United States in 1966.*

Services Performed

A package contains or holds merchandise, protects it, unitizes it, and communicates a message about it. These packaging services also imply that the package makes a product easier to handle and ship, display and sell.

A distinction can be made between two kinds of packaging: packing and packaging proper. Packing is used predominantly to aid in the handling, shipping, and warehousing of a product. Although packing also protects the contents and carries a message identifying the contents, protection and communication are frequently of secondary importance whereas containment is the paramount consideration. The most generally known example of packing is the corrugated box in which other packages are shipped. Canned goods, for example, are already well protected by the can, carry a unitized amount of merchandise, and their colorful labels proclaim the basic sales message. In order to ship these small containers efficiently, however, a container is necessary to hold them. The corrugated box is that container.

---

*The 350-million-ton figure excludes demolition wastes, scrapped automobiles, agricultural wastes, and mining wastes.

Packaging proper is mainly used to unitize, protect, and to communicate a message about a product. Unitization is implied by the term "packaging." The package contains either a measured quantity of product or it holds one or more units of a product. Unitization can take place either during the sales transaction or it may be accomplished well before the sale is made. An example of unitization during the sale is the butcher's action in weighing and packing a pound of ground beef, taken from a tray, while the shopper waits. Packaging is an example of unitization before the sale. For this reason, some observers prefer the term "pre-unitizing" to describe this particular packaging service.

Protection of the contents is a fundamental packaging function. The package acts as a barrier, in the widest sense of the word, against environmental forces which may adversely affect the contents during storage, handling, shipment, warehousing, display, sale, and use. Protection is afforded, depending on the contents, against physical impacts, scratching, abrasion, oxidation, heat, cold, the effects of light and gases, biological contamination, and similiar influences. Additionally, packages may be designed to frustrate pilferage and the activities of curious consumers wishing to see the contents.

Product protection and communication are closely linked. Protection frequently takes the form of total enclosure, thus hiding the contents. These must be identified. Of course, communication goes well beyond product identification; it must also sell the product, and the package, at times, is designed to do nothing more than to convey a sales message. The most obvious example of such a package is a colorful poster to which the product, in a container, is attached. The poster is unnecessary for functional purposes, but it makes the product appear larger and attracts attention. In yet other cases, protection and communication are accomplished at one stroke by using translucent or clear packaging which shows the contents while protecting them.

Both the degree of protection afforded by the package and the intensity of the communication are relative to the product packaged, its sales price, end use, and similiar factors. Food staples tend to be well protected to safeguard perishable contents; the sales message may be vigorously expressed but will not take novel forms. By contrast, novelty items, depending on impulse buying to achive a sale, tend to wear more showy packaging garments.

In addition to the basic services packaging performs, certain specific packaging categories are also designed to provide convenience in dispensing the product (aerosol can, milk bottle with a handle, cereal box with a spout, beverage can with rip-off closure, etc.) and in use of the product (frozen dinner package, boil-in-bag container, etc.). Yet other packages are manufactured for secondary use—for example, cereal boxes which can be made into paper dolls or games after they are emptied.

Technological Base

Packaging is a form of materials processing. The package manufacturer sizes, shapes, and joins paper, metals, glass, wood, plastics, and textiles to obtain a desired package configuration. The package is then filled and closed and is then usually packed for shipment. Many kinds of materials processing techniques are used to produce packages, for instance the nailing of wood, laminating materials, glass blowing, steel forming, and other similar activities which call for complicated equipment.

Most important from the technological point of view is that the package manufacturer almost always combines dissimilar materials to make a package. A glass bottle will typically be capped by a metal closure with a cork or plastic gasket. A steel can will be coated with tin, soldered, and wrapped with a paper label held in place by a combination of water-based and hot-melt adhesives. Most flexible paper wraps are coated with wax or plastics and may be laminated to a metallic foil. Corrugated and solid fiber boards are frequently coated or used in combination with coated inner liners, cellulosic "windows," as substrates for plastic shrink wrap, etc. Plastic films often appear in combination with paper, plastic bottles come with metal caps, plastic boxes with metal hinge supports. The list could be expanded at will; the above examples, however, suffice to suggest the multitude of material combinations encountered in packaging.

This proliferous intermarriage of materials is basic to packaging. Each distinct material and material combination offers specific performance advantages and disadvantages which make it suitable or undesirable for a given product. Advantages or disadvantages may relate to physical performance, machinability, weight, size, appearance, etc. Since a very large number of technological and economic factors interact in this field, it is difficult to predict future developments in packaging. A new but expensive material, for instance, could penetrate a market because it permits faster machinery speeds. Similarly, a new coating could make a weak and cheap material stronger, thus qualifying it for competition with a superior substance selling at a higher price. The development of a printing ink compatible with a substrate not heretofore printable can equip the substrate for entry into new markets.

Packaging, then, rests on a complex of technologies including materials chemistry, materials forming and joining, and material handling. It is influenced by food chemistry, transportation technology, innovations in graphic reproduction, and a host of other seemingly unrelated activities.

Markets

Packaging materials reach two distinct markets: the consumer and industrial/commercial buyers. On the basis of dollar expenditures, the consumer spends by far the greater amount on packaging. Three quarters of all expenditures are made by residential householders.

Industrial and commercial markets for packaging resemble each other and may be considered a single outlet. From the packaging point of view, both industrial and commercial containers serve to move goods in bulk or in unitized quantities larger than those which the consumer buys. The package is seldom designed to carry a sales message. And although industrial and commercial concerns also purchase packages in all configurations, a considerable proportion of their expenditures are for packages never encountered in a home.

The approximate distribution of packaging expenditures between the consumer and the industrial/commercial buyer for package configurations common to both market sectors was compiled for the package types that accounted for approximately 90 percent of all expenditures on packaging from 1958 to 1963 (Table 1). The remaining expenditures were made up of wooden containers, steel drums and pails, textile sacks, fiber drums, and similar bulk containers.

By far the largest user of consumer packages was the food industry, followed by beverages and chemical products (Table 2). A closer look at the expenditures of these three industries (Table 3) reveals that canned and frozen foods, malt liquors, and cosmetics, respectively, were the product groupings which led expenditures in these end-use markets. These commodity categories absorbed nearly 30 percent of all consumer packaging outlays.

Supplying Industries

However convenient it is to speak of a packaging industry, such an entity does not exist. Packages are manufactured by a number of industries, using inputs from yet other industrial or

TABLE 1.—*Distribution of packaging output by selected end use: 1958–1963* [a]

Percent

End use	Consumer packaging expenditures	Industrial/commercial packaging expenditures
Corrugated board [b]	45. 0	55. 0
Fold/san boxes	73. 7	26. 3
Set-up boxes	68. 1	31. 9
Wrappers	75. 7	24. 3
Labels	93. 3	6. 7
Fiber cans	100. 0	([c])
Metal cans	88. 3	11. 7
Metal collapsible tubes	89. 3	10. 7
Aerosol packages	97. 1	2. 9
Aluminum foil	84. 1	15. 9
Closures	91. 8	4. 3
Glass containers	95. 7	8. 2
Polyethylene	92. 7	7. 3
Plastic jars	88. 1	11. 9
Cellophane	95. 0	5. 0
All packaging	77. 1	22. 9

[a] Expressed as a percent of a five-year average dollar value of packaging, 1958–1963.

[b] Estimated by Midwest Research Institute.

[c] Minimal.

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging*, 20(2): 8–11, July 1967. Modified by Midwest Research Institute.

TABLE 2.—*Distribution of packaging outputs to selected consumer packaging end-use markets: 1958–1963* [a]

End-use market	Percent of total
Food	43.7
Beverages	12.6
Chemicals and allied products	11.7
Paper, printed and allied products	3.9
Textile and apparel	2.7
Hardware	2.4
Petroleum products	1.9
Tobacco and related products	.9
Toys, jewelry, etc	.7
Miscellaneous and other	19.5
Total	100.0

[a] This percent distribution is derived from a distribution of output to selected end-use markets for the five years, 1958–1963. It is based on dollars and covers about 75 percent of all packaging.

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging,* 20(2): 8–11, July 1967. Modified by Midwest Research Institute.

TABLE 3.—*Distribution of packaging output to selected consumer packaging end-use markets: 1958–1963* [a]

End-use market	Percent of total expenditures		
Food and kindred products:			
Meat products		3.3	
Dairy products		7.7	
Canned and frozen foods:			
Canned and cured seafoods	0.5		
Canned specialties	2.8		
Canned fruits and vegetables	6.7		
Dehydrated food products	.5		
Pickles, sauces, etc	1.4		
Fresh, frozen, and packaged fish	.3		
Frozen fruits and vegetables	2.0		
Other	1.3		
Total, canned and frozen foods			15.5
Grain mills		2.1	
Bakery products		4.2	
Sugar		1.0	
Confectionary		5.3	
Fats and oils		2.0	
Miscellaneous		2.6	
Total, food and kindred products			43.7
Beverages:			
Malt liquors		6.6	
Soft drinks		2.8	
All other		3.2	
Total, beverages			12.6
Chemical and allied products:			
Medicinals and pharmaceuticals		2.1	
Cosmetics, toiletries, etc		7.2	
Paints, varnishes, etc		1.3	
Miscellaneous chemical products		1.1	
Total, chemicals and allied products			11.7
All other industries			32.0
Grand total			100.0

[a] Same basis as Table 2.

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging,* 20(2): 8–11, July 1967. Modified by Midwest Research Institute.

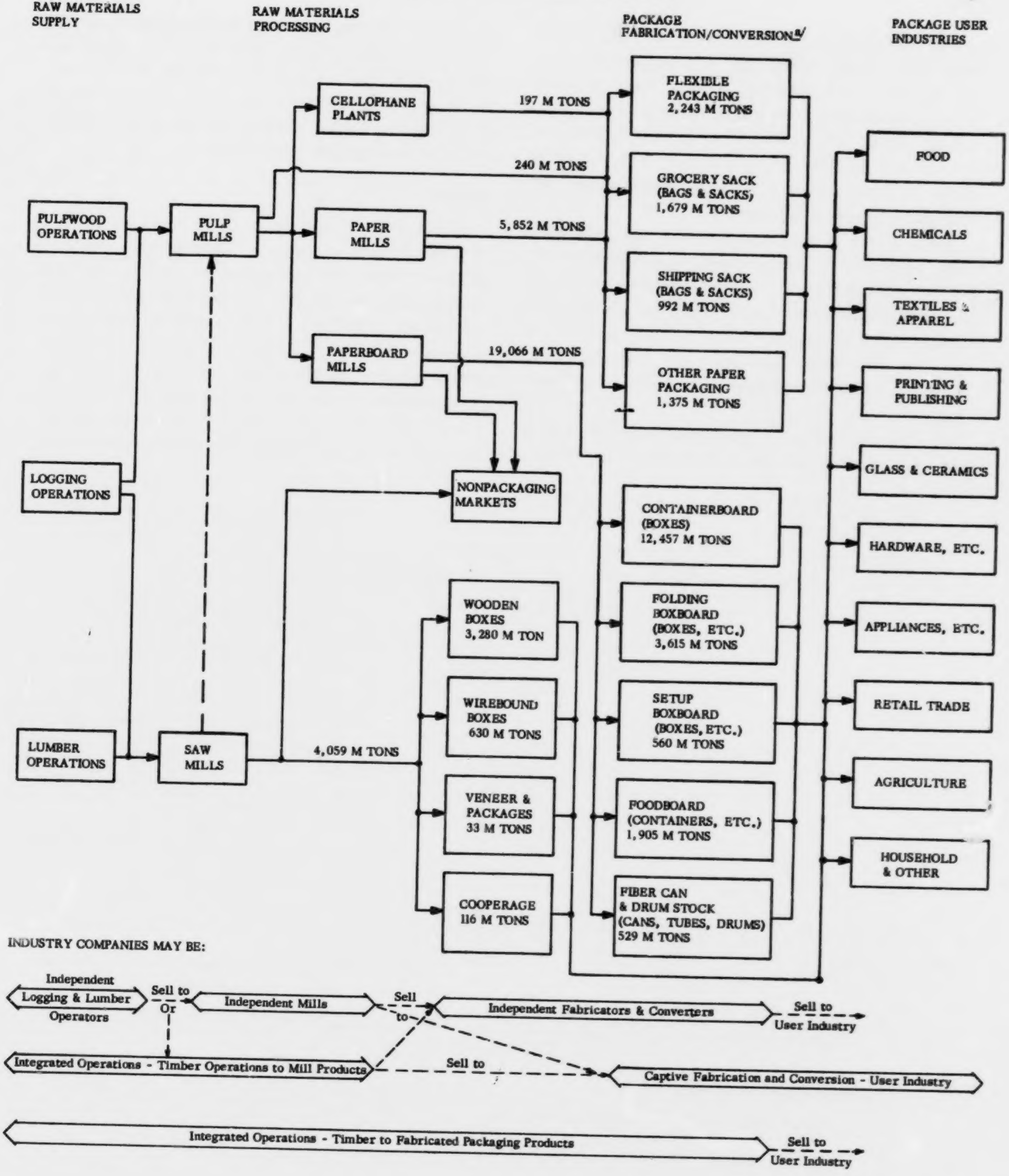
service groups. Depending on the base material used and its processing technology, the quantity of the basic material converted to packaging, the particular configuration, and the product to be contained, the package manufacturing step may be performed by the raw material processor, an independent converter or fabricator, the packager, or the retail merchant (e.g., fresh vegetable or meat packaging). Even the consumer acts as a package fabricator when he wraps a Christmas gift or a postal package using suitable materials.

Different industrial structures have grown up—and are still evolving—for the fabrication of packages made from the various major materials. The nature of the package supplying industries can best be grasped by looking at each of the materials industries separately.

Paper and Paperboard

Paper and paperboard package manufacturing is a highly integrated activity (Figure 1). The typical large paper company obtains its virgin fiber from wholly owned pulpwood forests and is capable of converting the tree into a package. The package buyer needs only to fill, seal, and label the container. At least part of the reason for such a high degree of integration is that a large percentage of total paper and paperboard production enters packaging markets (about 25 percent of paper, 85 percent of paperboard), thus creating sufficient volume to justify installation of converting facilities tied to raw materials production. In industries where packaging volume is not great in relation to total production of the basic material, far less integration is encountered.

Integration, however, is not strictly applicable to all paper and paperboard configurations or all operations. For instance, the manufacture of set-up boxes is usually handled by small companies serving limited geographical areas. These contain-


RAW MATERIALS SUPPLY
RAW MATERIALS PROCESSING
PACKAGE FABRICATION/CONVERSION a/
PACKAGE USER INDUSTRIES
PULPWOOD OPERATIONS
LOGGING OPERATIONS
LUMBER OPERATIONS
PULP MILLS
SAW MILLS
CELLOPHANE PLANTS
PAPER MILLS
PAPERBOARD MILLS
NONPACKAGING MARKETS
197 M TONS
240 M TONS
5,852 M TONS
19,066 M TONS
4,059 M TONS
FLEXIBLE PACKAGING 2,243 M TONS
GROCERY SACK (BAGS & SACKS) 1,679 M TONS
SHIPPING SACK (BAGS & SACKS) 992 M TONS
OTHER PAPER PACKAGING 1,375 M TONS
CONTAINERBOARD (BOXES) 12,457 M TONS
FOLDING BOXBOARD (BOXES, ETC.) 3,615 M TONS
SETUP BOXBOARD (BOXES, ETC.) 560 M TONS
FOODBOARD (CONTAINERS, ETC.) 1,905 M TONS
FIBER CAN & DRUM STOCK (CANS, TUBES, DRUMS) 529 M TONS
WOODEN BOXES 3,280 M TON
WIREBOUND BOXES 630 M TONS
VENEER & PACKAGES 33 M TONS
COOPERAGE 116 M TONS
FOOD
CHEMICALS
TEXTILES & APPAREL
PRINTING & PUBLISHING
GLASS & CERAMICS
HARDWARE, ETC.
APPLIANCES, ETC.
RETAIL TRADE
AGRICULTURE
HOUSEHOLD & OTHER
INDUSTRY COMPANIES MAY BE:
Independent Logging & Lumber Operators
Sell to Or
Independent Mills
Sell to
Independent Fabricators & Converters
Sell to User Industry
Integrated Operations - Timber Operations to Mill Products
Sell to
Captive Fabrication and Conversion - User Industry
Integrated Operations - Timber to Fabricated Packaging Products
Sell to User Industry

a/ Fabricators and converters may make packages from other material as well as paper or paperboard.

Source: Midwest Research Institute.

FIGURE 1.—Paper, paperboard, and wood packaging—Industry structure and flow chart: 1966

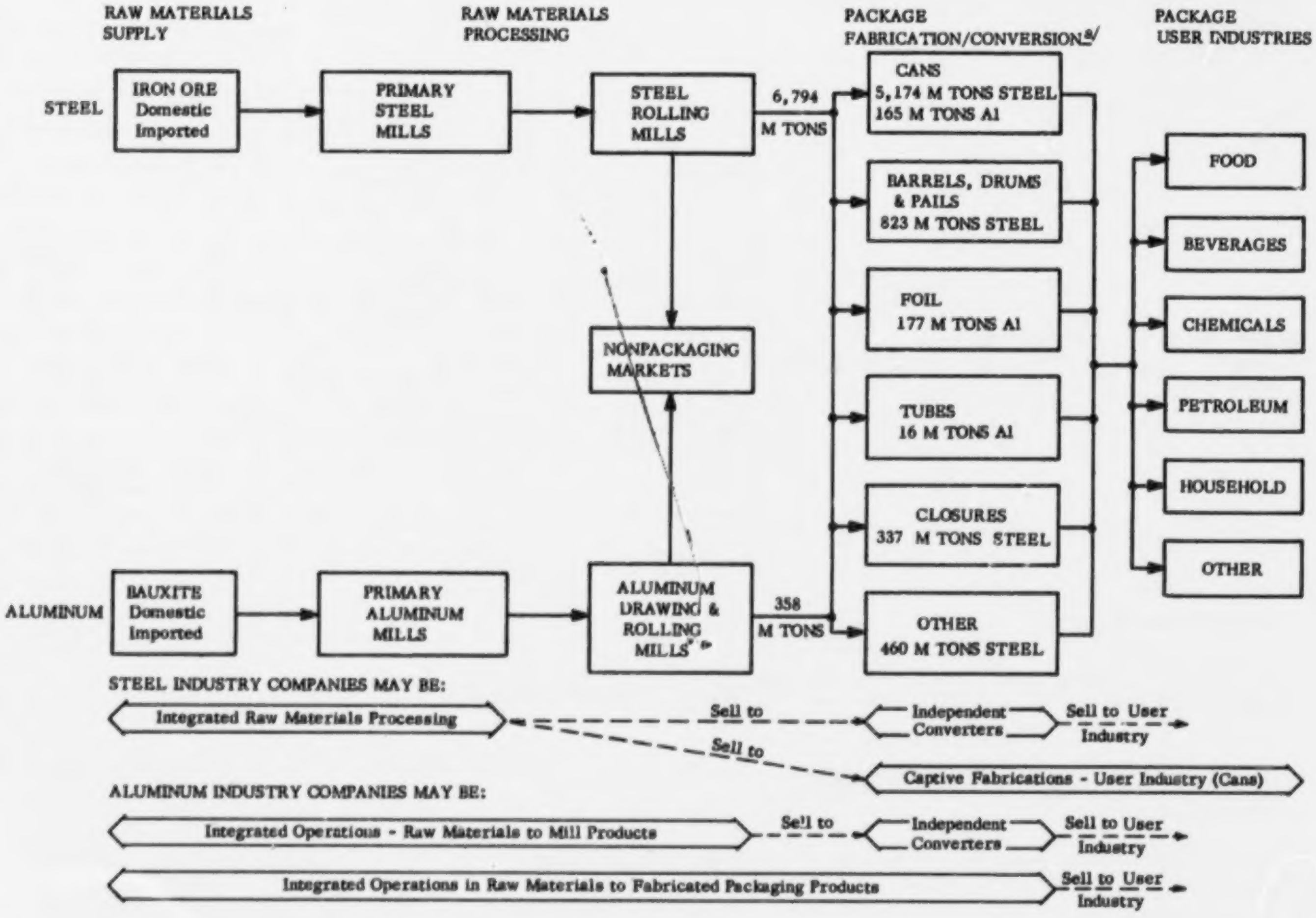
ers are shipped in finished form—standing rather than flat. Since much air is transported when set-up boxes are shipped, freight rates preclude their manufacture at points far from the user. Also, set-up boxes are produced in a wide variety of types; few of the types achieve a sufficiently large volume to justify their manufacture by integrated paper producers.

Some paper is also converted by the packager, who buys the required stock and fabricates it into a package in his own conversion facilities. In such a case, the justification for the captive facility may be found in the large quantities of uniform packages used by the manufacturer, which he can produce more profitably in his own shop.

Certain operations in paper package conversion are also performed by independent operators, primarily printing, glazing, and coating of papers. Where an entrepreneur outside of the paper industry does such work, the volume of material to be printed, glazed, or coated is usually large, or the job calls for custom tailoring of the end product to a specific requirement.

Metals

The industrial structure which has evolved for the production of metal containers is slightly different from the one found in paper, and the reason may be sought in the fact that metal containers represent a much smaller percentage of the steel industry's output (Figure 2). In 1963, only 9 percent of the industry's output ended up as containers, primarily metal cans. With such a relatively small percentage of its total volume earmarked for packaging, the steel industry has


RAW MATERIALS SUPPLY
RAW MATERIALS PROCESSING
PACKAGE FABRICATION/CONVERSION a/
PACKAGE USER INDUSTRIES
STEEL
IRON ORE Domestic Imported
PRIMARY STEEL MILLS
STEEL ROLLING MILLS
6,794 M TONS
CANS 5,174 M TONS STEEL 165 M TONS Al
BARRELS, DRUMS & PAILS 823 M TONS STEEL
FOIL 177 M TONS Al
TUBES 16 M TONS Al
CLOSURES 337 M TONS STEEL
OTHER 460 M TONS STEEL
NONPACKAGING MARKETS
FOOD
BEVERAGES
CHEMICALS
PETROLEUM
HOUSEHOLD
OTHER
ALUMINUM
BAUXITE Domestic Imported
PRIMARY ALUMINUM MILLS
ALUMINUM DRAWING & ROLLING MILLS
358 M TONS
STEEL INDUSTRY COMPANIES MAY BE:
Integrated Raw Materials Processing
Sell to
Independent Converters
Sell to User Industry
Sell to
Captive Fabrications - User Industry (Cans)
ALUMINUM INDUSTRY COMPANIES MAY BE:
Integrated Operations - Raw Materials to Mill Products
Sell to
Independent Converters
Sell to User Industry
Integrated Operations in Raw Materials to Fabricated Packaging Products
Sell to User Industry

a/ Package fabricators and converters may make packages from other materials as well as steel or aluminum.

Source: Midwest Research Institute.

FIGURE 2.—Metal packaging—Industry structure and flow chart: 1966

not found justification to integrate forward into can making and is engaged only in production of sheet steel for packaging uses.

Steel containers are manufactured by independent converters or by packagers from rolled tinplate purchased from the steel industry. Examples of converters are American Can, Continental Can, and National Can. Examples of packagers with captive can manufacturing facilities are Campbell Soup Company and Carnation Company. The bulk of can output (80 percent) is manufactured by independent converters under contract to the packager.

A somewhat different arrangement characterizes aluminum can production. Although aluminum packages also account for only a small proportion of total aluminum output (perhaps 8 percent), aluminum producers are also package producers. Reynolds Metals Company and Kaiser Aluminum both manufacture beer cans in direct competition with independent fabricators who may also be their customers. Another segment of the industry, exemplified by Alcoa, has chosen not to compete with converters and restricts its activity to the sale of aluminum stock to independent fabricators.

The different approaches adopted by steel and aluminum producers trace to the different degrees of packaging market penetration by steel and aluminum. Steel is well established; aluminum is aspiring. In its efforts to create a larger market for its material, a part of the aluminum industry is willing to go to some length to establish its product, including the construction of a can manufacturing plant serving a large user. Historical excess production capacity in this industry has also led to nontraditional marketing approaches, such as competition with its own customers, a novel departure in the metal packaging industry.

Glass

Glass technology is the governing factor shaping the glass package manufacturing industry. Unlike other packaging materials, glass cannot be shipped as an intermediate raw material to a converter for shaping. Glass containers must be formed as part of the overall glass production process. For this reason, the glass producer is also always the container producer. He ships the product to the packager for filling, sealing, and shipment (Figure 3).

Plastics

Corporate approaches to the production of plastic packages illustrate once more that raw materials producers will assume converting functions as soon as sufficient packaging volume has been created (or is anticipated) to make such a move appear profitable. Until recently, plastic resins, supplied by chemical companies and petroleum refiners, were converted into packages or films almost exclusively by independent converters. In the past few years, Du Pont, Monsanto, Union Carbide, Dow, Phillips, Tenneco, and other resin suppliers have moved into resin conversion and today make films, bottles, and tubes. Some major package manufacturers (e.g., American Can and Owens-Illinois) have also acquired in-house capabilities to convert resin into finished packages. The plastics packaging industry appears to be in a state of transition—from a decentralized structure in which raw material processors showed little interest in end products to one in which the raw material producers have integrated forward to embrace conversion functions (Figure 4).

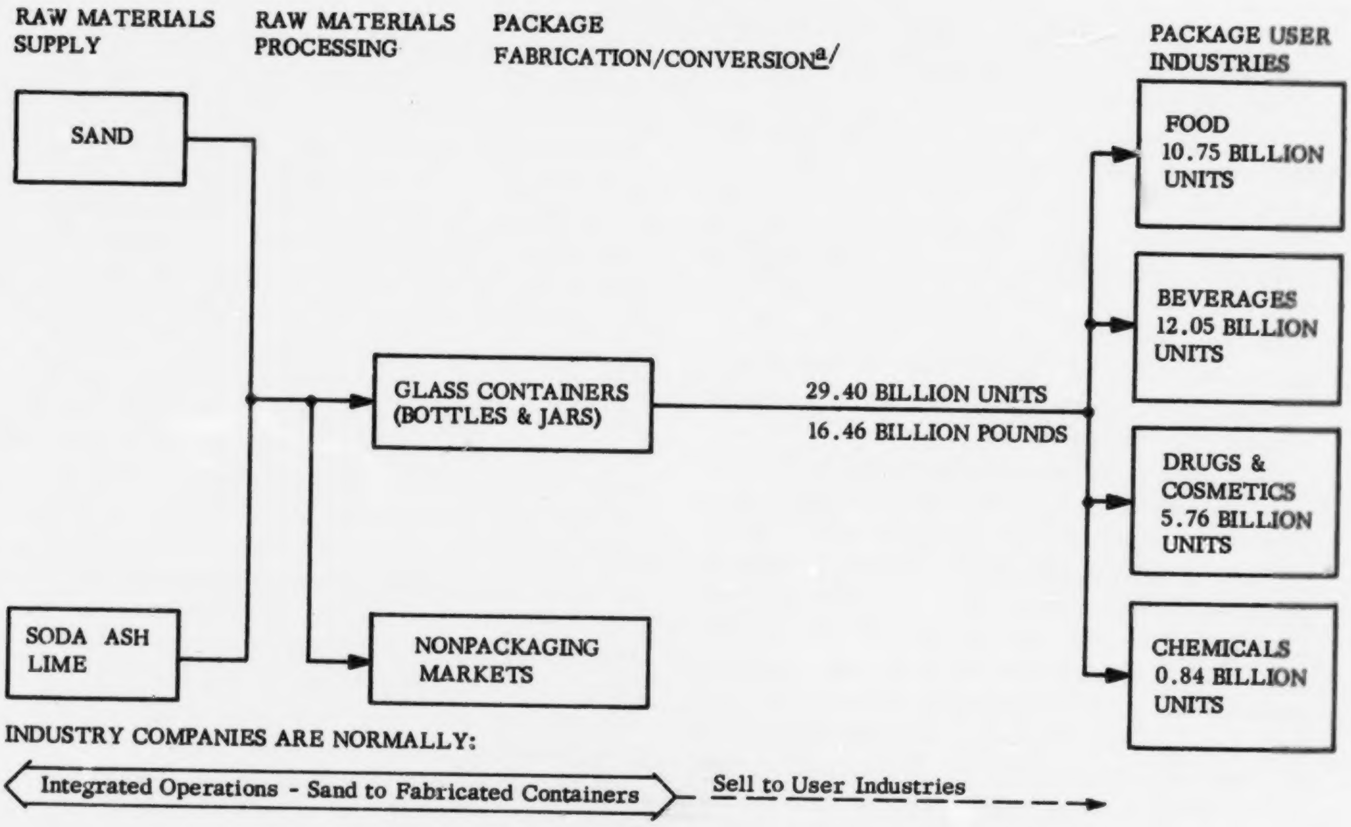
These moves are explained by the growth of plastics in packaging. On the whole, this market accounts for 18 to 20 percent of all plastics sold on a tonnage basis. But the percentages do not tell the entire story. Certain plastics, for example polyvinyl chloride, play a very minor role in packaging. About half of all polyethylene produced, however, goes into packaging. In addition to the present consumption situation, raw materials producers also view the future with optimism—a view fully borne out by MRI forecasts. Plastic usage in packaging is expected to double by 1976 on a tonnage basis.

Wood

With only 3 percent of their output taking the ultimate form of a package, the nation's saw mills have not integrated forward into package manufacturing. Wood is usually converted into packages by independent fabricators (Figure 1).

BASIC TRENDS IN PACKAGING

Much more packaging will be consumed per capita in the next decade than in the previous one. There will be more kinds of packages on the market and packages will be compounded of dissimilar materials. These statements summarize the basic trends in packaging as they are expected to


RAW MATERIALS SUPPLY
RAW MATERIALS PROCESSING
PACKAGE FABRICATION/CONVERSION a/
PACKAGE USER INDUSTRIES
SAND
SODA ASH LIME
GLASS CONTAINERS (BOTTLES & JARS)
NONPACKAGING MARKETS
29.40 BILLION UNITS
16.46 BILLION POUNDS
FOOD 10.75 BILLION UNITS
BEVERAGES 12.05 BILLION UNITS
DRUGS & COSMETICS 5.76 BILLION UNITS
CHEMICALS 0.84 BILLION UNITS
INDUSTRY COMPANIES ARE NORMALLY:
Integrated Operations - Sand to Fabricated Containers
Sell to User Industries

a/ Package fabricators and converters may make packages from other materials as well as glass.

Source: Midwest Research Institute.

FIGURE 3.—Glass packaging—Industry structure and flow chart: 1966

appear in the next 10 years. A look at each trend in detail follows.

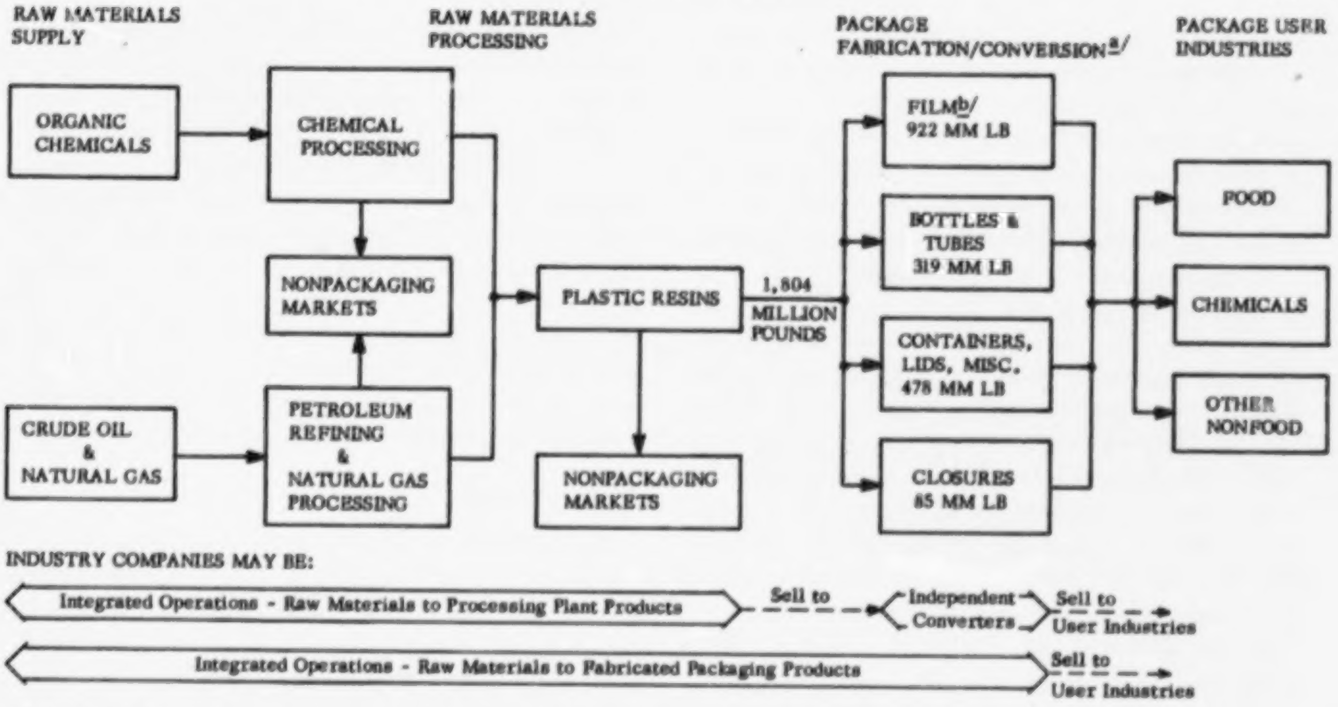
More Packaging Consumption per Capita

At the root of this trend is the rise of self-service merchandising. In such a distribution system, the influence of the sales clerk is eliminated. Products on shelves mutely vie for the consumer's favor. Items which are attractively packaged have an advantage over products lacking flashy garments in such a situation, with the consequence that packaging has penetrated into areas where it has not been used traditionally. Lettuce wrapped in plastic film, hand tools encased in shrink-wrap plastics, and textile products bagged in paper or plastics are examples, along with many items of hardware, toys, garden supplies, etc. which are packaged today whereas, in the recent past, they were displayed in bins or placed on shelves without wrappings. Overall, this means that the volume of products reaching the consumer in packaged form is increasing, and with the proliferation of such products, packaging materials consumption per capita will rise.

Increasing Number of Package Types

This trend also rests in part on the emergence of the self-service store as the dominant form of merchandising today and in the future. In self-service outlets, products must sell themselves. This has led to an unprecedented degree of package differentiation in recent years. The reason: packages must stand out to attract the consumer—and differentiation accomplishes this aim by use of bolder colors, unusual materials, greater size ranges, novel shapes, and so forth.

While the types of packages have been multiplying in response to competitive pressures encountered in the self-service store, the same forces have also given birth to many new products. To


RAW MATERIALS SUPPLY
RAW MATERIALS PROCESSING
PACKAGE FABRICATION/CONVERSION a/
PACKAGE USER INDUSTRIES
ORGANIC CHEMICALS
CHEMICAL PROCESSING
NONPACKAGING MARKETS
CRUDE OIL & NATURAL GAS
PETROLEUM REFINING & NATURAL GAS PROCESSING
PLASTIC RESINS
1,804 MILLION POUNDS
NONPACKAGING MARKETS
FILM b/ 922 MM LB
BOTTLES & TUBES 319 MM LB
CONTAINERS, LIDS, MISC. 478 MM LB
CLOSURES 85 MM LB
FOOD
CHEMICALS
OTHER NONFOOD
INDUSTRY COMPANIES MAY BE:
Integrated Operations - Raw Materials to Processing Plant Products
Sell to
Independent Converters
Sell to User Industries
Integrated Operations - Raw Materials to Fabricated Packaging Products
Sell to User Industries

a/ Package fabricators and converters may make packages from other materials as well as plastics.
b/ Excludes cellophane.
Source: Midwest Research Institute.

FIGURE 4.—Plastic packaging—Industry structure and flow chart: 1966

look at a single industry, frozen, pressurized, freeze-dried, and instant foods are some examples of relatively recent product innovations in food. These new products call for new modes of packaging or different types of containers. Satisfaction of emerging packaging needs has led to—and is still causing—the multiplication of the types of packages on the market.

A third reason for this trend is intermaterials competition. For instance, a product which traditionally has been packaged in paper will usually come in a bag, on a paper tray, or in a box-like container. When plastics or glass invade the packaging market for such a product, different package shapes frequently appear, but the new packages may not entirely displace established forms, with the result that a number of new types of containers are available for the same product. Until recently, shampoo could only be purchased in glass bottles. Today it is available in glass bottles, in plastic bottles, and in flexible plastic tubing.

Package types are multiplied also by attempts to provide shopping convenience and to move goods with the same merchandising effort. Multi-packing has been one result. In a multi-pack, several items are combined into a single sales unit by packaging: several cans, bottles, flashbulbs, gaskets, ink cartridges, etc. If the consumer desires one of these items, he must purchase several. Similarly, the consumer may wish to buy several units, and his purchase is facilitated by having them conveniently united. This type of packaging has given rise to new kinds of containers—and is also partly accountable for higher consumption of packaging materials per capita.

The manufacturer must compete for shelf space for his goods. Packages which are easier to remove from the master container, hold up well in storage, maintain their brightness and attractiveness under artificial light, and are difficult to pilfer and damage tend to be preferred by the retail merchant over products which are deficient in one or more of these service or performance categories. Novel packages, which the merchant recognizes as potentially attractive to his customers, tend to be featured—especially so if they come in master containers which are convertible into display cases. The desire to provide a package attractive to the retail merchant also translates into the multiplication of package types.

A final reason for the appearance of new types of packages is the popularity of the working package and secondary use package. A working package is one which helps dispense the product or aids in connection with use of the contents. Secondary use packages are those which can be utilized for some purpose after they are emptied.

The homemaker is most articulate in her condemnation of packages which are difficult to work with. She vigorously condemns hard-to-open containers—but also containers which are difficult to reseal adequately after they have been opened. She likes to have a wide choice of package sizes, and she tends to reject packages which do not fit her refrigerator or shelving. She dislikes breakable containers in her bathroom. Finally, she does not like the logistical problems involved in returning deposit type containers.

What does she like? The homemaker likes packages which make her job easier. She is an inveterate collector of containers which are usable for storage and flexible materials in which she can wrap leftovers, lunches, and household items. The enthusiastic reception of coffee cans equipped with plastic lids and the popularity of frozen foods, boil-in-bag vegetables, and instant food preparations illustrate the homemaker's preference.

Consumer preference for convenience in packaging and secondary use containers promotes package type multiplication. Manufacturers are increasing the size or volume range of their packages: detergents are available in sizes ranging from "giant" sized boxes to small packages sufficient for a single load of wash; portion-packed cereals complete with family-sized boxes; dog food may be purchased in a cereal box or in a huge paper or plastic sack containing a month's supply; milk is available in containers ranging from half-pint size up to 5 gallons. Multiplication of package sizes is observable in most consumer packaging areas. Significant is the fact that new package sizes do not displace existing configurations but are presented as new alternatives to the consumer.

Production of conveniently sized or unitized products is only one reaction to the demand for convenience. The consumer is also given the option to buy a product in a discardable package or one which can be retained for secondary use. Jelly containers which become drinking glasses are one example of the latter. The nonreturnable bottle and beverages packaged in metal cans are responses to the consumer's demand for "disposable" packages. Frozen pies and full-course dinners which can be prepared in the package; twist-off type closures for beverage containers; a variety of plastic boxes and tubs to hold food staples; and the packaging of foods, cosmetics, paints, and sprays under pressure for ease of use are all developments which increase the number of types of packages available and which result from the consumer's predilection for more easy-to-use and reusable containers.

More Complex Packages

As packages are called upon to fulfill more and more functions beyond product containment and protection, their costs increase. Intense competition for the buyer's approval, however, does not permit the manufacturer to pass the entire cost of the package on to the consumer. If at all possible, he must obtain the desired package qualities and functions at a low cost.

In recent years, this has resulted in considerable activity on the part of the package manufacturers, package buyers, and material producers to exploit to the maximum whatever technology is available to produce the desired packaging products and to minimize their costs. Activities have included the use of newer materials, combinations of materials, the use of less material per unit of product packaged, packaging machinery improvements, and a host of other innovations which help cut total merchandising costs while maintaining and upgrading package quality.

Innovative activity has been especially noteworthy in the past five or six years and is largely attributed to the appearance of plastics in packaging. Many observers would date the impact of plastics from 1960, when the price of polethylene dropped. This precipitated intermaterials competition on a new level of intensity. Plastics, since then have become strong contenders for packaging markets. Producers of other materials have reacted to the threat from plastics by steps to improve their materials, thus equipping these for the competitive struggle. The end of this war of materials for packaging markets is not yet in sight. While it persists, packaging will be characterized by rapid change on the technological front.

The key to understanding inter-materials competition and technological change lies in the nature of the materials themselves. Each packaging material class has definite advantages and disadvantages in physical performance as a package or in package forming, in cost, in appearance, or in a combination of these. Advantages and disadvantages are also related to the product to be packaged. Some require barrier coatings; others do not. Some look attractive when displayed through a translucent covering; others are best hidden behind an opaque surface. The package designer, looking at his product and at the multitude of material options open to him, must find his way to a container which maximizes the advantage inherent in a suitable combination and minimizes the disadvantages. He must hit upon a configuration which gives him optimum performance at minimum cost.

This situation is difficult to present with precision because in the manufacturer's language, "performance" does not refer strictly to physical characteristics but to physical characteristics *and* the more nebulous packaging attributes which lead to sales growth ("warmth," "gloss," "novelty," etc.). Similarly, "cost" does not refer only to material price and production expenses but also includes outlays for filling the package, its transport (lighter, less bulky packages are preferred, for instance), refrigeration costs, the losses associated with spoilage and breakage, and others. When all of these elements are included, a package which may appear to be more expensive on the basis of material price alone may turn out to be the cheapest solution to a particular packaging problem.

Packaging manufacturers have always combined dissimilar materials. What is significant today is that the number of materials suitable for combination has increased dramatically with the advent of plastics, whose many varieties and combinations of varieties have been added to the list of traditional substances used in this field. Along with the appearance of plastics has come development of new coating and adhesive technologies which permit the combination of materials which have not, heretofore, appeared in union. The considerable increase in the options available to the package manufacturer, coupled with the demand for new and better packages, is the predominant reason for the wave of innovation sweeping packaging today.

Package manufacturers have not fully exploited or explored the possibilities of this changed technological base in packaging. Such exploration of new choices and use of new materials lies in the future. As packagers move toward application of new technology, packages are expected to become more complex in composition.

PAPER AND PAPERBOARD

Paper and paperboard dominate the packaging materials field. In terms of tonnage, paper and paperboard accounted for 55 percent of all packaging consumed in 1966.* About half of the production of the paper and paperboard industry is used for packaging purposes (25.2 million tons of a total 46.6 million tons in 1966).

There are many reasons for the dominant position of paper and paperboard in packaging. Paper can package almost any item that does not need the exceptional protective characteristics obtainable with metal, glass, or plastic containers. It is a relatively inexpensive, highly machinable, strong, and printable material. Paper can be combined with other materials to improve its performance characteristics and can be formed into a wide variety of rigid, semi-rigid, and flexible containers. Even when paper is not the primary package for a particular item, it is likely to be the secondary package and also the container in which the product is shipped to market. For example, aspirin is packaged in a glass bottle, the bottle is put inside a paperboard box, and then many of these small boxes are packed in a corrugated container to be sent to retail outlets.

There are three basic groups of paper and paperboard. The largest is paperboard, or rigid papers. The second largest grouping is flexible packaging papers made up of coarse grades of paper (grocery bags, shipping sacks, wrapping paper, converting paper), and glassine, greaseproof, and vegetable paper. The third and smallest grouping is specialty papers, which includes tissue paper, fine grade printing and converting papers, and wood pulp. Specialty papers are most often used as parts of other packaging such as labels, wraps, pouches, and crate fillers.

---

*In all paper and paperboard categories the quantity was based on tonnage production instead of consumption expressed as shipments. For practical purposes however, production and consumption were considered to be equivalent. Production figures were used because of the readily available statistical information by paper and paperboard grades; conversely, the multitude of packaging applications for paper and paperboard result in uneven statistical data by end uses, some being very good and others practically nonexistent. In the case of the other materials—metal, glass, plastics, wood, and textiles—the actual consumption figures were used.

The following tabulation (Table 4) shows the relative dominance of the three groups of paper and paperboard in packaging in millions of pounds and in percentage of total for the years 1966 and 1976,

Table 4.— *Production of packaging grades of paper and paperboard: 1966 and 1976*

Type	1966		1976	
	Lbs (Millions)	Percent	Lbs (Millions)	Percent
Paperboard	38, 131	75. 8	58, 500	79. 2
Flexible paper	9, 434	18. 7	11, 780	16. 0
Specialty paper	2, 751	5. 5	3, 570	4. 8
Total	50, 316	100. 0	73, 850	100. 0

Source: Midwest Research Institute.

Paper and paperboard are produced from three principal types of raw materials: virgin fiber, paper stock, and other fibers. Virgin fiber is wood pulp obtained from trees and plants; it provides a broad range of furnish* for all grades of paper and paperboard. Paper stock, a trade term for waste paper, comes from a wide variety of sources including mill and conversion scrap as well as waste paper and paperboard acquired on the open market. Other fibers are primarily rag, straw, bagasse, and plant waste stocks. In recent years the use of virgin pulp has increased while the use of other fibers and of paper stock has declined.

Papermaking is a highly developed technology centering on the conversion of pulpwood into a finished product. The industry has learned to use more of each tree and to use trees that formerly were not cut for pulping purposes. The supply of pulpwood has been increasing because of advances in forest technology, resulting in improved yields and more efficient production methods.

Paper stock is still widely used in making certain grades of paper and paperboard, and is used primarily by paperboard manufacturers, who consume about 75 percent of all paper stock used for paper product furnish. However, the markets for paper stock are subject to rapid changes in supply and demand, one reason why consumption of this raw material has not kept pace with total paper and paperboard output.

Paperboard

Paperboard is the largest single group of packaging materials from a quantity standpoint. Consumption has been growing steadily since 1958. In that year, 24 billion pounds of paperboard packaging grades were produced. By 1966, production had increased to 38 billion pounds; this quantity represented 36.8 percent of all packaging (Table 5). The 1966 tonnage translated into more than 199 billion package units (Table 6). The strong and steady growth of paperboard is derived from its broadly based service as a utility material in packaging at relatively stable prices. Since 1956, paperboard prices have ranged between $119 and $123 per ton. Other materials have increased in price in the same period, particularly in recent years.

There are five major types of paperboard, each of which will be discussed separately: containerboard, set-up boxboard, special foodboard, folding boxboard, and can, tube, and drum stock.

Containerboard

Corrugated and solid fiber are the two basic kinds of containerboard. Corrugated is by far the most important; it accounts for 99 percent of the total square feet of board produced. Consequently, the terms "containerboard" and "corrugated board" are used interchangeably. There are three kinds of corrugated: (1) double face, a fluted sheet glued between layers of liner material, (2) single face, a fluted sheet with a liner on only one side, and (3) double wall, two or more lined fluted sections. Double face corrugated accounts for more than 90 percent of all corrugated, double wall for 8 percent, and single face for 1 percent (Table 7).

Containerboard is made from kraft paper and small amounts of jute straw and fibered chip. The resulting material has long fibers and is

---

*"Furnish" is a trade term used to designate the fibrous product entering paper- and paperboard-making machines.

TABLE 5.—*Production of packaging grades of paperboard: 1958 to 1966*

In millions of pounds

Paperboard	1958	1959	1960	1961	1962	1963	1964	1965	1966
Containerboard	14, 519	16, 465	16, 374	17, 323	18, 593	19, 277	20, 684	22, 398	24, 915
Folding boxboard	5, 380	5, 782	5, 846	5, 975	6, 241	6, 434	6, 591	6, 867	7, 229
Special foodboard	2, 609	2, 889	2, 894	3, 046	3, 242	3, 346	3, 503	3, 673	3, 809
Set-up boxboard	1, 077	1, 152	1, 050	994	1, 048	1, 054	1, 068	1, 095	1, 120
Tube, can, and drum stock	492	669	628	668	745	973	1, 048	1, 174	1, 058
Total paperboard	24, 077	26, 957	26, 792	28, 006	29, 869	31, 084	32, 894	35, 207	38, 131

Source: U.S. Department of Commerce, Bureau of the Census. Pulp, paper, and board—1966. *Current Industrial Reports* Series M26A (66)-13. Washington, D.C., 1967. American Paper Institute, Inc., Paperboard Group. *Paperboard Industry Statistics—1966*, Chicago. May 1967. p. 15. Fibre Box Association, *Fibre Box Industry Statistics—1966*. Chicago, April 1967. p. 29.

TABLE 6.—*Consumption of paperboard packages by type: 1958 to 1966* [a]

In millions of containers used

Type	1958	1959	1960	1961	1962	1963	1964	1965	1966
Corrugated and solid fiber	9, 746	10, 976	10, 853	11, 504	12, 027	12, 856	13, 776	14, 850	16, 513
Folding paper boxes	120, 815	121, 910	131, 765	135, 707	147, 825	149, 650	153, 227	156, 293	164, 542
Set-up boxes	5, 950	6, 369	5, 621	5, 256	5, 574	5, 579	5, 601	5, 744	5, 875
Cans and tubes	4, 836	5, 840	5, 658	5, 913	7, 045	8, 724	9, 965	11, 352	12, 958
Drums	26	29	29	30	32	32	34	36	39
Totals	141, 373	145, 124	153, 926	158, 410	172, 503	176, 841	182, 603	188, 275	199, 927

[a] This compilation is an estimate (by *Paperboard Packaging*) based on judgment about average material consumption per unit. Certain sanitary containers are excluded, e.g., milk cartons.

Source: *Paperboard Packaging*, 52(8): 31 August 1967. Modified by Midwest Research Institute.

TABLE 7.—*Containerboard types: Description and relative importance: 1966*

Type of containerboard	Description	Percent of total containerboard [a]
Corrugated double-face board.	Fluted sheet placed between two layers of kraft liner material.	90
Corrugated double-wall board.	Two or more double-face boards combined into a single board.	8
Corrugated single-wall board.	Fluted sheet lined on one side only by kraft paper.	1
Solid fiber board	Single layer of stiff, solid fiber.	1
Total		100

[a] Based on square feet produced.

Source: Fibre Box Association. *Fibre Box Industry Statistics—1966*. Chicago, April 1967. p. 16.

strong. Corrugated is relatively low in cost. The average price in 1955 was $15.77 per 1,000 square feet; the 1966 price was $16.52. Solid fiber, basically cardboard, is more expensive and sells for about $39 per 1,000 square feet.

Uses: Almost all containerboard is used for boxes or interior packings. Containerboard boxes are used primarily as shippers for pre-packed items and also as packing containers for a variety of products—furniture, appliances, toys, etc. (Table 8). The material is also popular as a liner, padding, and partitioning material in interior packing. Solid fiber, because of its relatively high cost, is used primarily for special applications.

Corrugated is sold in large quantities because it serves utility packaging functions as a shipper and it is a strong material that effectively contains, protects, and cushions the contents.

New Developments: There is little that is new in the basic construction and composition of

TABLE 8.—*Distribution of corrugated and solid fiber shipping containers to end-use markets: 1958–1966*

Percent of shipments based on square footage shipped

End-use markets	1958	1959	1960	1961	1962	1963	1964	1965	1966
Beverages	3.1	3.2	3.5	3.1	2.9	3.3	3.1	3.2	3.5
Food and kindred products	25.4	24.7	24.7	25.6	24.1	24.8	25.1	26.0	26.3
Tobacco	.8	.8	.8	.9	.8	.8	.7	.7	.6
Carpets, rugs and other floor covering	.4	.5	.5	.4	.4	.4	.3	.3	.3
Textiles (except carpets, rugs, etc.)	3.1	3.2	3.2	3.3	3.8	3.2	3.0	3.0	3.1
Apparel	1.5	1.5	1.4	1.6	1.6	1.4	1.5	1.6	1.1
Lumber products, except funiture	.9	1.0	.8	.9	.9	.8	.8	.8	.9
Household funiture	3.6	3.1	3.8	2.9	2.7	2.4	2.5	2.2	1.9
All other furniture and fixtures	1.6	1.8	1.6	1.4	1.4	1.2	1.2	1.1	1.1
Paper and paper products	9.4	9.6	9.9	9.7	9.7	9.7	9.5	10.4	11.3
Printing, publishing, and allied industries	1.3	1.3	1.5	1.6	1.5	1.7	1.5	1.4	1.3
Soaps, cleaners, cosmetics, perfumes, etc	2.2	2.6	2.9	2.4	2.2	2.6	2.4	2.3	2.5
Paints and varnishes	.6	.6	.6	.7	.5	.6	.6	.5	.5
Chemicals and allied products (except paints and varnishes, and soaps, cleaners, perfumes, cosmetics, etc.)	2.9	2.7	2.8	2.5	3.1	3.0	3.1	3.0	3.3
Paving and roofing material	.9	.8	.7	.7	.4	.4	.3	.2	.2
Products of petroleum and coal (except paving and roofing material)	1.1	1.1	1.0	1.0	.9	.9	.8	.8	.9
Rubber and miscellaneous plastic products	1.7	2.0	1.9	2.5	3.1	2.9	3.5	3.4	3.3
Leather products	.6	.5	.4	.5	.4	.4	.4	.4	.4
Stone, clay, and glass products	9.1	9.1	8.6	9.9	10.6	10.1	9.9	9.7	8.8
Primary metal products	1.1	1.2	1.1	.9	.9	1.0	1.0	1.1	1.0
Fabricated metal products	7.1	7.1	6.9	6.3	6.0	5.5	5.5	5.5	4.4
Service-industry machinery	1.0	1.1	1.0	.8	.9	.9	.6	.7	.7
Other machinery (except electrical and service industry machinery)	2.0	1.9	1.5	1.5	1.5	1.6	1.7	1.5	1.6
Electrical machinery, equipment, and supplies	3.0	2.7	2.5	2.3	2.2	2.3	2.3	2.5	2.5
Electrical appliances	1.9	2.8	2.5	2.7	2.5	2.5	3.0	3.0	3.5
Communication equipment and related products	1.3	1.1	1.1	1.0	1.0	1.0	.9	1.0	1.0
Transportation equipment (except motor vehicles and motor vehicle equip.)	.7	.8	.7	.7	.6	.6	.5	.6	.6
Motor vehicles and equipment	3.0	3.0	3.1	2.6	3.3	3.1	3.1	2.8	2.7
Professional and scientific instruments	.8	.6	.7	.6	.6	.6	.7	.6	.6
Toys, sporting, and athletic goods	1.4	1.6	1.6	2.3	2.5	2.4	1.9	1.9	1.6
Miscellaneous manufacturing (except toys, sporting, and athletic goods)	6.2	5.7	[illegible]	6.3	6.5	7.5	8.2	7.3	7.9
Government	.3	.3	.3	.4	.5	.4	.4	.5	6

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging*, 20(2): 6, July 1967.

containerboard. Technological developments in coatings and bulk packaging, however, have brought about some changes in commercial applications and have improved the performance of corrugated boxes.

Coatings of wax, a variety of hot-melt substances (wax-plastic combinations), plastics, lacquer, and latex are being used on corrugated. These coatings may serve a variety of purposes—to provide a protective barrier, to increase the wet strength of the board, or to add to the attractiveness of the container.

Coatings are not extremely important in all-purpose utility shippers, but they are playing an increasingly important role in special duty containers and consumer packaging. For example, coated corrugated containers are now used in shipping top-iced goods such as poultry, seafood, and fresh fruit as well as water-cooled goods such as fresh vegetables. In consumer packaging, coatings are used to improve the appearance and to protect the contents from abrasion and scuffing.

Coatings are also being used in combination with bleached liners and printing ink to produce attractive shipper-display boxes. These containers have assumed considerable importance as a result of the tremendous growth of self-service and discount stores. Shipper-display boxes do not represent a significant change in technology; they do, however, shift the point of disposal from commercial outlets to households.

Although the use of coated corrugated will increase in the next 10 years, it is unlikely that such boxes will account for a large share of corrugated: coated stocks are used primarily for low volume, specialized purposes. In some cases, coated corrugated will displace other packaging materials, such as wire-bound boxes used to ship poultry and fresh fruits. In other cases, coating of the board will make a higher quality, better appearing box ideally suited for consumer packaging. When thrown away, the box will be more difficult to process in disposal because of the coating.

Recent developments in bulk packaging technology, particularly in the packaging of utility goods such as canned foods, are significant because of their potential effect on the use of regular corrugated containers. Two techniques—skrinkase (shrink-wrapped tray cases) and paper bundling—would, if widely adopted, noticeably reduce the amount of corrugated used. A third technique—corrugated wrap around—may help corrugated to maintain its present dominant position.

Shrink-wrapped trays are produced by placing a number of cans, usually 12, on a corrugated tray. A sleeve of shrinkable plastic is then placed over the tray (or two stacked trays) and the tray is passed through a heat tunnel where the film is shrunk tightly around the cans and holds them securely in place. The product is then ready to be sent anywhere without any additional packaging.

One of the main advantages of shrink-wrapped trays is that they are easy to handle at the retail level: the film can be stripped away and the trays can be stacked on top of each other. In addition, it is not necessary to dispose of bulky corrugated boxes.

The potential for shrink-wrapped trays is considerable. If used only for canned food packing, the process could displace 25 percent of the corrugated presently in use. This, however, is unlikely to occur: shrinkase costs about 30 percent more than regular corrugated containers. And, while it is possible that technological advances will cause price reductions, we do not expect this to happen within the time-frame of this report.

Present shipping regulations present yet other obstacles to the widespread use of shrink-wrapped trays. The trucking industry has approved shrinkase only for certain products; the railroads are even slower to act; they have approved shrinkase only for test shipping. Reluctance of the railroads to pass favorably on shrink-wrapped goods stems from the fact that these plastic-wrapped containers are somewhat less durable in rough handling and much more likely to burst upon impact and to spill their contents.

Paper bundling is a more promising innovation. In this technique, kraft paper is wrapped tightly around containers for shipping. Usually only rectangular items can be wrapped in this way. Paper bundling may be accepted as a means of packaging certain boxed foods and household items, e.g., cereals and detergents.

Paper bundling has certain advantages over corrugated—it costs 2 to 4 cents less per unit, gives excellent crush resistance to the bundle, makes the contents less prone to vibration damage, weighs less per unit, and is less bulky. Transporters are opposed to paper bundling because excessive in-transit damage can occur. Since paper bundling eliminates the corrugated tray, retailers dislike the technique; it causes difficulty in storing and shelving opened bundles.

Corrugated wrap-around systems have also made their appearance. This packaging procedure is essentially the same as paper bundling except that corrugated rather than kraft paper is used. A product bundle of 12 or 24 units is gathered together, and corrugated is folded around the entire product load. The procedure results in a tight, stackable, shock resistant package. However, a rather large capital investment is necessary to purchase the fairly complex machinery used for corrugated wrap-around systems.

The corrugated industry is continually developing new types of packaging in order to retain its share of the shipper market. The industry has developed pallet bins that can hold up to 2,000 pounds, containers with more wet strength, collapsible bulk carriers, six-, eight-, or 12-sided containers, and multi-walled constructions for better protection and heavy duty service.

Outlook: In view of the above developments, we believe that containerboard will continue to be the largest single packaging material from a volume standpoint in the 1966- to 1976-period. This forecast recognizes the fact that containerboard will lose some markets to plastic films and single-ply papers; however, containerboard producers are anticipating such competition and making technical improvements (among them new coatings, superior machinery, new handling systems, and stronger containers) which will expand corrugated markets to new uses.

In 1958 containerboard production stood at 14.5 billion pounds; by 1966 production had increased to 24.9 billion pounds—a growth rate of about 7 percent annually. For the 1966 to 1976 decade, we forecast a slightly slower rate—5 percent per year. In terms of quantity, this rate means that 40.6 billion pounds of containerboard will be produced in 1976.

Boxboard

There are three types of boxboards: set-up, folding, and special food board. Boxboards are composed of solid fiber grades of paperboard made from virgin fibers or paper stock. Altogether, 12.2 billion pounds of these materials were produced in 1966 (Table 9).

Set-up Boxboard: Most set-up boxboard is made into rigid boxes. The material is stiff and has poor bending qualities. While it is the cheapest paperboard made, it is usually converted into high quality packaging; the unattractive board is covered with a quality grade, fine paper having a glossy, metallic, textured, or printed finish, to produce a box which combines attractiveness with strength. Textiles, hosiery, shoes, leather goods, candy, cosmetics, stationery, photographic supplies, and jewelry are typically packaged in set-up boxes (Table 10).

Most set-up boxboard manufacturers are small companies which do not have research budgets. Technological advances in machinery and handling have been slow and modest as a consequence and are likely to continue to be so. This is expected to have a depressing effect on boxboard. Box buyers are increasingly turning to competing materials and containers, for example plastic boxes and folding paperboard. Some boxboard outlets, however, particularly photographic supplies, cosmetics, candy, stationery, toys and games, certain textiles, and office supplies are fairly secure markets for boxboard. Buyers in these industries view the rigid box as the most functional form of packaging for their products and are likely to continue using it even as they demand better quality and fancier decoration. In response, boxmakers are expected to use new wrapping and printing methods; they will also combine boxboard with plastics, cellophane, and foil; and they may use higher quality paperboard stock.

In spite of such innovative activity, we foresee a decline in the amount of set-up boxboard that will be produced. In 1966, 1.1 billion pounds were made; by 1976, production is expected to have declined to 906 million pounds—a 1.5 percent annual market erosion.

Folding Boxboard: Folding boxboard is a paperboard used to produce inexpensive, simple, and printable packages. Printing and display characteristics are especially important, and folding boxboard packages often have cutout windows for display or functional purposes. About 76 percent of all folding boxboard is used for folding cartons, such as cereal boxes, frozen food cartons, cracker boxes, soap and detergent boxes, beverage cartons, and a wide variety of other containers. Folding boxboard is also used for diecut backs of blisterpacks, displays, lids, and the like (Table 11).

TABLE 9.—*Boxboard production: 1958–1966*

In millions of pounds

Boxboard type	1958	1959	1960	1961	1962	1963	1964	1965	1966
Set-up boxboard	1,077	1,152	1,050	994	1,048	1,054	1,068	1,095	1,120
Special food board	2,609	2,889	2,894	3,046	3,242	3,346	3,503	3,673	3,809
Folding boxboard	5,380	5,782	5,846	5,975	6,241	6,434	6,591	6,867	7,229
Total boxboard production	9,066	9,823	9,790	10,015	10,531	10,834	11,162	11,635	12,158

Source: American Paper Institute, Paperboard Group. *Paperboard Industry Statistics—1966*. Chicago, May 1967. p. 15.

TABLE 10.—*Distribution of set-up paper boxes to end-use markets: 1958 to 1966*

In percent of total dollar shipments

End-use markets	1958	1959	1960	1961	1962	1963	1964	1965	1966
Textiles, wearing apparel, and hosiery	26.6	29.0	24.1	21.5	28.8	24.6	16.7	18.7	27.3
Department stores and other retail stores	13.5	15.3	15.3	11.4	12.6	15.8	14.1	14.3	12.3
Cosmetics	2.4	4.1	5.1	6.1	5.9	6.8	7.7	9.2	10.9
Confections	7.7	9.6	7.3	10.6	9.4	12.4	11.1	12.8	7.5
Drugs, chemicals, pharmaceuticals	2.0	2.5	6.3	4.0	2.9	4.8	4.8	4.3	5.3
Jewelry and silverware	7.1	1.8	4.9	6.1	5.0	4.2	8.0	6.2	4.1
Stationery and office supplies	5.5	7.5	7.2	6.9	6.7	5.5	6.0	7.1	4.3
Hardware, household, and auto	6.7	6.9	6.7	2.8	3.2	3.6	3.0	3.7	1.3
Toys and games	2.4	2.0	2.7	3.0	1.8	2.8	1.9	2.1	1.9
Shoes and leather goods	6.5	6.2	5.0	2.6	4.6	3.0	1.8	1.4	3.4
Food and beverages	.8	1.2	1.2	1.3	1.2	1.4	2.7	1.2	1.2
Photographic products and supplies	.7	3.1	3.9	4.9	3.3	2.4	2.9	1.3	4.1
Sporting goods	1.0	1.1	1.0	1.0	.7	1.1	1.9	1.0	1.5
Other major customers	7.6	4.3	2.9	(1)	(1)	5.6	7.9	11.6	8.4
Miscellaneous	9.5	5.4	6.4	17.8	13.9	6.0	9.5	5.1	6.5

[1] Included in miscellaneous.

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging*, 20(2):7, July 1967.

TABLE 11.—*Distribution of folding paper boxes to end-use markets: 1958 to 1966*

In percent of total tonnage shipments

End-use markets	1958	1959	1960	1961	1962	1963	1964	1965	1966
Armed forces and quartermaster	0.1	0.1	0.2	0.2	0.4	0.2	0.1	0.2	0.4
Medicinal products	3.7	3.9	3.7	3.7	3.7	3.7	3.8	3.7	3.2
Cosmetics and personal accessories	2.3	2.4	2.5	2.5	2.6	2.9	3.2	3.5	2.4
Soap	11.1	11.6	11.9	12.4	12.3	12.6	12.3	12.3	8.8
Food, except candy and baked goods	23.9	23.5	23.7	24.5	24.0	24.1	23.5	25.3	33.9
Candy and confectionery	4.9	4.7	4.9	5.0	4.8	4.3	4.1	4.4	4.8
Crackers and baked goods	10.7	10.5	10.5	9.6	9.3	8.7	8.6	8.6	9.4
Tobacco and related products	4.7	3.1	2.5	2.2	2.2	2.0	1.9	1.7	3.0
Hardware, appliances, and automotive supplies	4.5	5.6	5.5	5.4	5.7	5.8	5.9	5.7	5.1
Sporting goods and toys	1.2	1.3	1.3	1.4	1.4	1.3	1.3	1.4	1.3
Textiles and apparel	4.7	4.9	4.7	4.5	5.1	4.8	5.4	4.7	3.3
Retail boxes	3.7	3.7	4.0	4.0	4.0	4.4	4.3	3.6	2.9
Laundry boxes	.4	.4	.4	.4	.5	.5	.5	.5	.5
Rubber goods	.9	.7	.6	.6	.6	.5	.6	.5	.5
Beverages	9.5	9.6	9.8	9.5	9.7	10.0	10.4	11.7	10.5
Paper goods or products	8.9	9.3	10.0	10.4	10.0	9.5	9.4	7.5	6.3
Miscellaneous	4.8	4.7	3.8	3.7	3.7	4.7	4.7	4.7	3.7

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging*, 20(2): 7, July 1967.

In recent years there has been a trend toward upgrading the quality of folding boxboard. Virgin fibers are being used more frequently at the expense of paper stock; improved finishes, coatings, full color printing, and other decorative techniques are more widely employed to improve appearance. Folding boxboard has also been combined with plastic sheets to form blisterpacks, skin packs, stretchable film packs, and similar combination packages. (In general, these last mentioned packages hold the product to a sheet of paperboard by means of a transparent plastic sheet; the sheet is heatformed to the contours of a die or to the product itself. Use of this type of packaging has been growing by leaps and bounds.)

Folding boxboard is in a period of intense competition with plastics and flexible packaging. Box manufacturers are responding to this competition with better quality and more attractive packages, while taking full advantage of opportunities offered by a "marriage" with their competitors in blisterpacks, skin packs, display containers, and the like. As a result they should be able to offset their losses to competing materials. Most folding boxboard will continue to be used as the base for functional containers in high volume consumer products—cereals, cleansing tissues, medicinals, etc. The rapid growth of no-return beverage containers is also providing a relative new high volume application for no return cartons too. However, in the next 10 years, folding boxboard will continue to grow at a relatively slow rate of about 2.8 percent per year; production is expected to increase from 7.2 billion pounds in 1966 to 9.5 billion pounds in 1976.

Special Food Board: Special food board is made from solid, bleached, virgin-fiber paperboard. It is used for rigid containers that have high moisture barrier properties and highly printable outer surface finishes.

This board is used almost exclusively for packaging foods—primarily dairy products and frozen foods (Table 12). Nearly half of the material is used to produce milk cartons. A large proportion of special food board is coated with polyethylene, hot-melts, or wax. Plastic coating of paperboard is a relatively recent phenomenon and should continue to grow. In 1955, 42.8 million pounds of special food board were coated with 11.2 million pounds of plastics. In 1966 the figures had risen to 1,588 million pounds of special food board and 186 million pounds of plastic coatings. This large increase is attributable to the substitution of extruded polyethylene for wax in milk carton coatings, a development which took place in the 1960 to 1964 period.

The technology of food board packaging is well advanced. Food board, however, is beginning to feel some stiff competition from various types of plastic containers. One example is the all-plastic milk bottle. The special food board carton is now being used for a variety of new product applications—popcorn, fountain syrups, potato flakes, meat sauces, and other specialty foods, applications also vulnerable to plastics. The food board industry can be expected to use more foil laminations and more polyethylene and hot-melt coatings to improve the barrier properties and attractiveness of these paper containers. Additionally, new forms such as nested cup-and-pail styles and plate, dish, and tray styles will be used more widely for packaging direct consumer purchase items such as cottage cheese, ice cream, fresh meat, and produce.

These technological moves will counteract the effects of competition from plastics, which are expected to penetrate deeply into food board markets in many areas, especially milk, ice cream, cottage cheese, butter, and margarine packaging.

Barring legislative action,* the growth rate of special food board will largely depend upon the relative cost of competing plastic containers and

TABLE 12.—*Special foodboard production by end use: 1958 to 1966*

In millions of pounds

End use	1958	1959	1960	1961	1962	1963	1964	1965	1966
Milk cartons	1, 024	1, 099	1, 142	1, 201	1, 357	1, 354	1, 384	1, 504	1, 564
Paraffin cartons, paperboard pails, and frozen food cartons	685	790	737	774	762	837	914	905	864
Heavy weight cups, round nested food containers, and cup lids	517	576	575	626	649	651	658	687	739
Liquid tight containers, milk bottle hoods, and plugs	83	85	110	101	96	80	85	67	68
Plates, dishes, and trays	206	231	247	256	297	320	358	404	464
Other special food board uses	94	108	83	88	81	104	104	106	110
Total special food board	2, 609	2, 889	2, 894	3, 046	3, 242	3, 346	3, 503	3, 673	3, 809

Source: American Paper Institute, Inc., Paperboard Group. *Paperboard Industry Statistics—1966.* Chicago, May 1967. p. 17.

---

*New York City for example recently adopted legislation requiring that packaged meats be fully visible from all sides.

the forming and filling machinery these latter will need. If plastics penetrate the market to a greater degree than we think likely at this time, the actual volume of food board will decline. Plastics can penetrate the market to a greater extent, however, only if the container costs drop, more attractive machinery purchase plans are developed, or if consumers become inclined to pay a premium for more convenient, leak-proof, and attractive packages. The first two of these possibilities are likely to materialize relatively slowly; the consumer, on the other hand, has already demonstrated a preference for plastics, even at a higher cost. Consequently, it is difficult to make a confident forecast in this packaging category.

We assume that in the 1966 to 1976 period plastics will not become competitive with food board *in toto* even though they will have a significant impact on food board. An annual growth rate of 4.9 percent is most likely to characterize this material. Production should increase, as a consequence, from 3.8 billion pounds in 1966 to 6.1 billion pounds.

*Can, Tube, and Drum Stock:** Fiber cans, tubes, and drums are commonly made from heavy kraft papers in combination with other materials such as aluminum foil or plastic. The ends or rims of these containers are often composed of another material—wood, plastic, or metal—to produce a composite package. The use of composite cans and tubes has increased in recent years. Their chief advantages are lower cost and lower weight per unit than all-metal cans.

The three major markets for composite cans are refrigerated dough products, frozen citrus juice concentrates, and motor oil (Table 13). About 1.4 billion composite containers are used every year to package refrigerated dough. An equal number of composite cans are currently used to package motor oil. In addition to these products, composite cans are used extensively for citrus juices, other food products, and paint.

Fiber tubes are frequently used for mailing purposes and also serve as cores to provide inner support for products such as wax paper, paper towels, and aluminum foil.

TABLE 13.—*Distribution of fiber can and tube shipments: 1965 and 1966*

Fiber and composite fiber cans—end use	Million units 1965	Million units 1966
Food products:		
Frozen citrus juices	985	996
Refrigerated dough products	1,395	1,421
Other food products	([a])	([a])
Non-food products:		
Motor oil	1,306	1,365
Other non-food products	([a])	([a])

Tubes and cores	Millions of pounds (net weight) 1965	Millions of pounds (net weight) 1966
Spiral tubes and cores	478	524
Conglued tubes and cores	74	80
Total	552	604

[a] Not available.
Source: National Fibre Can and Tube Association. *Fibre Can and Tube Industry Statistics*, 1967.

TABLE 14.—*Fiber drum shipments by end use: 1966*

End use	Percent of units
Foods and related products	15
Soaps and detergents	6
Pharmaceuticals	7
Plastics—molding compounds and resins	17
Chemicals	41
Abrasives, metal powders, wire alloys, stampings, machine parts	6
Rolled materials	2
Direct sales to government and other	6
Total	100

Source: Bulk Packaging and Containerization Institute, Inc. "Fibre Drums Again Climb to New Records." Press release, August 1967.

Fiber drums are used as shippers of dry or semiliquid products (Table 14); 11 percent of all fiber drums, however, are used for carrying liquids. Fiber drums range in capacity from 5 to 55 gallons and, under Interstate Commerce Commission regulations, they are permitted to carry 550 pounds. In 1958, 26 million drums were shipped; in 1966 the figure was 38.3 million (Table 15). Fiber drums are frequently used for one-trip

---

*Can, tube, and drum stock is not the only paper grade used to make these items but is representative of the products described.

TABLE 15.—*Fiber drum shipments 1958 to 1966*

Year	Millions of units
1958	26.0
1959	29.2
1960	28.4
1961	29.7
1962	32.6
1963	32.2
1964	33.9
1965	34.7
1966	38.3

Source: Bulk Packaging and Containerization Institute, Inc. "Fibre Drums Again Climb to New Records." Press release, August 1967.

service, and they compete primarily with steel drums.*

Given the present state of technology, composite cans cannot be used for products that must be packaged under high pressure, vacuum, or high heat. The main technical frontier facing composite cans and tubes is development of higher barrier properties, at lower cost, than can be achieved by the materials now used. Aluminum foil is most commonly applied as a fiber can liner today; but aluminum is being replaced in some instances by polypropylene, polyethylene, ethylene vinyl acetate, hot-melt coatings, grease-proof paper, glassine, and plastic coatings and laminations.

Technological advances may well open up new markets for composite cans. For example, a seven-layer composite can was recently developed to hold shortening. The can consists of layers of polypropylene, aluminum foil, polyethylene, kraft paper, paperboard, and an aluminum foil outer label. This container performs as well as steel cans in providing effective grease and oxygen barriers. The composite is also cheaper and weighs 60 percent less than a steel can. The concept is adaptable to other products, such as containers for nuts, snack foods, and instant coffee.

One of the most important technical advances would be development of a composite can that could be used for packaging beer and soft drinks under heat, pressure, or vacuum. Such a development does not appear likely within the next five years.

The outlook for composite cans is generally favorable, but the growth of these containers will be relatively modest—2 to 3 percent per year—because they are not expected to penetrate into new large volume markets soon and because they already enjoy preeminence in packaging several non-pressurized liquids and semi-solid products. At the same time the oil can market is coming under increasing competitive pressure from both plastic and metal, and fiber composite cans are likely to yield ground here in the near future.

Should a technological breakthrough take place to qualify composite cans for markets now held by steel and glass, the growth rate would be considerably higher. A paper-based container could then enter the lucrative beverage packaging market or utility goods packaging. While we do not rule out such a breakthrough, we do not expect it to take place before the mid-1970's.

Research is also being conducted on ways to increase the suitability of fiber drums for shipping liquids. Plastic polyethylene linings have been developed in a variety of forms—extrusion coated kraft liners, blow-molded liners fused to the walls, and semi-rigid liners formed separately to be inserted into the drums. However, technological advances that increase the cost of fiber drums lessen their competitive position vis-à-vis steel drums.

In the next 10 years, however, fiber drums should have a growth rate of 3 to 4 percent a year. Increasing the use of fiber drums for liquids at the expense of steel and improved structural designs should help create this expansion in fiber drum use.

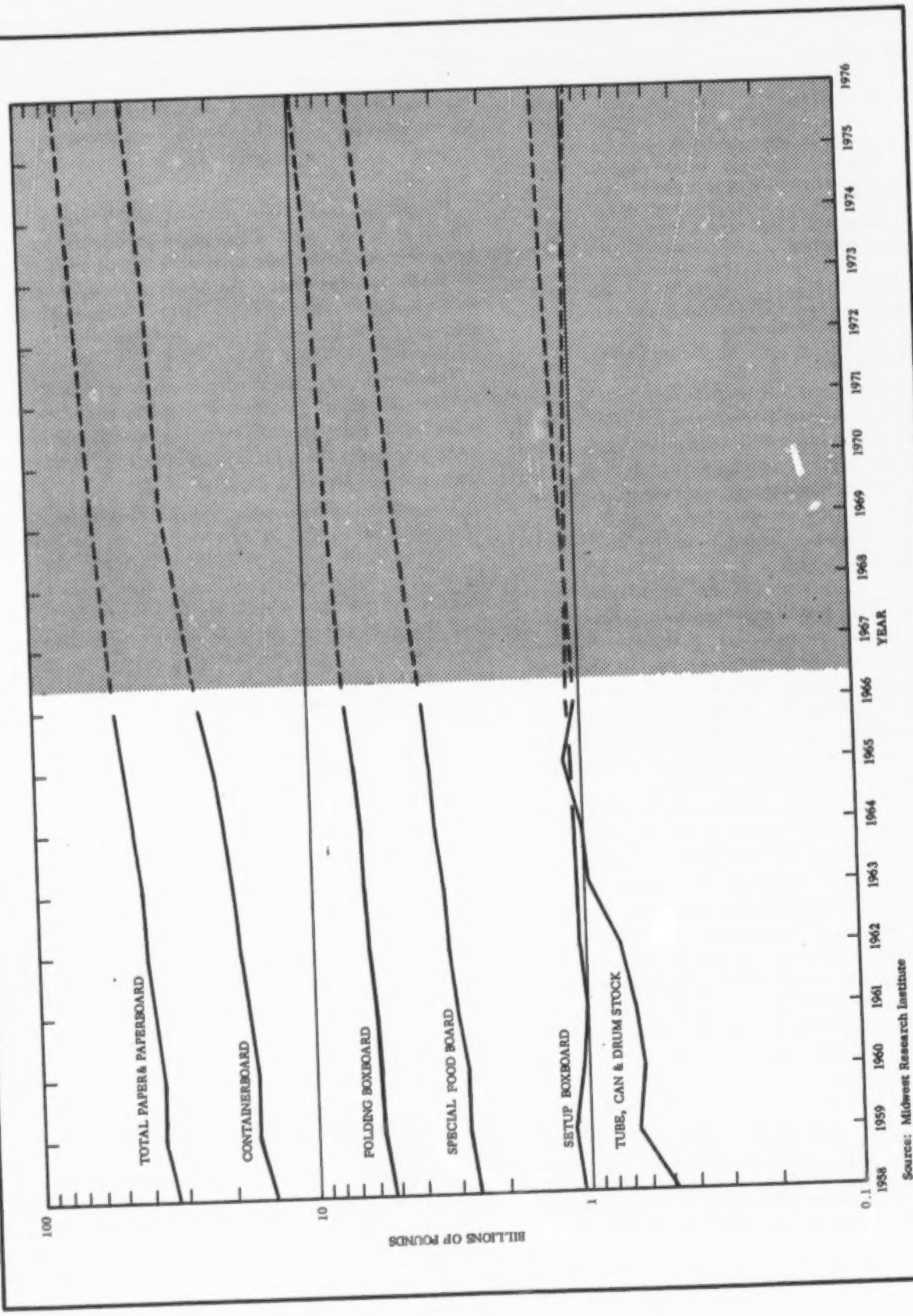
The total quantity of all fiber, can, tube, and drum stock produced in 1966 was 1.1 billion pounds. Consumption in 1976 should exceed 1.3 billion pounds, representing a 2 percent annual growth rate.

Paperboard—Summary Outlook

Of the five types of paperboards only one, set-up boxboard, will decline over the next 10 years. The other types will show increases of 2 to 5 percent. As a group, paperboard materials will have a growth rate of 4.4 percent in the 1966 to 1976 period (Table 16 and Figure 5).

---

*Fiber drums usually enter the waste stream at a slower rate than that suggested by one-trip use because the drums are often put to secondary uses, such as storage or trash barrels.



Source: Midwest Research Institute

FIGURE 5.—Consumption of paperboard in packaging: 1958–1976 (billions of pounds)

Table 16.—*Production of packaging grades of paperboard: 1966 and 1976*

Paperboard type	Millions of pounds		Ten-year rate of change (percent)
	Actual—1966	Forecast—1976	
Containerboard	24,915	40,580	5.0
Folding boxboard	7,229	9,530	2.8
Special food board	3,809	6,140	4.9
Set-up boxboard	1,120	960	−1.5
Tube, can, and drum stock	1,058	1,290	2.0
Total	38,131	58,500	4.4

Source: Midwest Research Institute.

Flexible Paper

Flexible papers* constitute the second major group of paper and paperboard materials. There are five major types of flexible paper: bag paper; converting paper; wrapping paper; shipping sacks; and glassine, greaseproof, and vegetable paper.

Flexible papers are used for a variety of basic packaging purposes. These papers are inexpensive, machineable, and easily combined with other materials such as plastic and aluminum foil to change their physical properties. These combinations add strength and stiffness to flexible papers or increase their resistance to moisture, grease, and gases.

Flexible papers are usually made from unbleached kraft paper. Flexible paper grades are coarse (as opposed to fine papers made from thinner stock and with a higher finish).

A significant amount of research is being done on ways to create a "plastic-paper" by combining the two materials. In one process, paper is impregnated with a thermoplastic monomer at the paper mill, and the impregnated paper is converted into a container. This process eliminates the step of separately coating paper with plastics. Another plastic-paper process involves encapsulating wood fibers in a polyolefin (e.g., polyethylene). The encased fibers are then formed into sheets and the result is a plastic-paper with the characteristics of both materials.

Neither process has been developed to the point of commercial application at this time, and very likely plastic-papers will not have a significant impact on packaging before the mid-1970's. However, these and other research activities should be watched for developments that may cause significant changes in the characteristics of packaging papers.

Bag Paper

Bag paper is the largest group of flexible papers. By far the most common bag paper product is the grocery sack, made from unbleached kraft paper. A small amount (one-eighth) of bag paper is converted into variety and specialty sacks used for carrying merchandise. These sacks are often bleached and printed.

Converted bag paper products are used primarily for sacking of groceries. The grocery sack is made of a heavy grade paper and comes in a variety of sizes, the most common capacity being one-sixth of a barrel (0.85 cubic feet).

The quantity of bag paper produced has grown at a relatively high rate in recent years—about 5 percent in the period from 1958 to 1966. The basic force behind this growth has been the expansion of retailing operations in supermarkets and chain stores. In addition, increased volume has been due to the practice of double bagging groceries. Double bagging is practiced because a single grocery sack is not always strong enough to hold heavy items, such as canned goods, and it also tears easily when it becomes moist after coming in contact with frozen foods and other items that may be damp.

New Developments: To overcome some of the disadvantages of grocer's sacks, double wall sacks have been developed. These containers eliminate the need for double bagging and cost around 25 percent more than single sacks. However, many store owners object to the price differential, and housewives often prefer two sacks so they will have a supply of these available for secondary uses at home, such as lining wastebaskets. Nonetheless, many retailers are expected to eventually adopt double wall sacks—in place of bagging.

Manufacturers have also experimented with sacks made of "extensible" paper. This paper is softer, more pliable, and stronger than regular paper bag stock, and it stretches when impacted rather than bursting. Housewives have not accepted extensible paper bags because the bags feel weaker, even though they are stronger than the ordinary grocery sack. (This paper has been accepted by many industrial packagers for sacks because of its high strength.)

---

*The flexible paper grades were analyzed in less depth than other packaging materials categories because of unavailability of specific information. Historical trends in consumption were the chief basis for making volume forecasts.

Variety and specialty sacks, used to carry merchandise from the retail store to the home, are increasingly being combined with metal foil, polyethylene, other plastic films and coatings, and wax base coatings. There is a general trend to higher quality bags with better strength, barrier properties, and more decoration.

In the future it is possible that the regular kraft paper bag will be replaced by an all-plastic lined or coated paper sack. At present, neither retailers, because of the cost, nor housewives, because of their dislike of flexible sacks, are willing to accept plastic sacks. However, new developments in plastic technology may enable manufacturers to overcome these problems.

One new application of paper sacks—as refuse containers—might considerably increase the volume of paper bag stock made. In some areas, large paper sacks have been found to be highly acceptable substitutes for metal refuse cans in trash collection. Use of disposable sacks can result in savings in labor and maintenance costs. Because of the savings, these sacks are likely to find ready acceptance in industrial and institutional refuse collection practice. Various industry sources have estimated that the potential U.S. market for paper refuse sacks is 2 billion or more pounds of paper per year. At present, the prime deterrent to the widespread acceptance of paper refuse sacks is cost—8 to 15 cents per unit. At the rate of two sacks per week at a cost of 10 cents per sack, use of paper would add about $10 per year to homeowner costs.

Outlook: Bag paper will continue to be accepted as a low cost product for grocery sacks and, when combined with other materials, as stock for variety and specialty sacks. Since supermarket retailing and other forms of merchandising are expected to continue to expand, the consumption of bag paper stock will also increase. During the 1958 to 1966 period, bag papers had a growth rate of almost 5 percent per year. We expect this growth rate to decline slightly—to 4.1 percent a year—primarily on the assumption that double walled sacks will become more important and partially displace double bagging (double walled sacks use less material than two separate sacks). The total number of pounds used in 1966 was 3.4 billion; in 1976, 5.0 billion pounds should be used.

Converting Paper

Converting papers are coarse grades, produced for converters who make the paper into some kind of package. Converting paper is also used for envelope and creping stock. More than half of the converting paper produced (58 percent) is made from unbleached kraft paper (Table 17).

During conversion, papers are usually coated or laminated with a variety of materials to increase their barrier properties. The most commonly used materials are asphalt, wax, polyethylene, lacquer, resin emulsions, plastic film, foil, and other papers, such as glassine.

Converting paper is frequently used for flexible packaging in the form of printed and laminated rolls, for a variety of bags and pouches, and for envelopes (manila and heavy-duty mailing), shipping sacks, cups, and other container forms.

Polyethylene and other plastic resins are replacing some of the older coating materials, such as wax and asphalt. Converters are constantly offering new combinations of converting paper and other materials to satisfy the packaging requirements of their customers. Converting paper, along with all other nonplastic materials, is encountering growing competition from plastics in flexible packaging. Paper's share of the total, for example, declined from 39.9 percent in 1962 to 38.5 percent in 1966. In the same period, polyethylene flexible has gone from 33.6 percent of the market to 39 percent, cutting into the share held by paper and cellophane.

Converting paper is a basic packaging material with an advanced and efficient production and conversion technology. The volume usage should remain stable for some time in spite of the competition from plastics. Wax- and asphalt-coated grades may decline in use, but this decline will be offset by the increased use of envelope stock and papers treated with other materials. We foresee a slow growth rate of 0.3 percent a year, and an increase in volume from 2.4 billion pounds in 1966 to 2.5 billion pounds in 1976.

Wrapping Paper

About two-thirds of all wrapping paper is made from unbleached kraft. Wrapping paper is coarse, strong, and economical. These papers are sometimes coated or impregnated with wax, polyethy-

TABLE 17.—*Production of converting paper by type: 1958 to 1966*

In millions of pounds

Type of converting paper	1958	1959	1960	1961	1962	1963	1964	1965	1966
Unbleached kraft:									
Asphalting paper including creping stock for asphalting	305	310	285	283	277	293	370	384	428
Other creping	50	52	49	47	32	26	25	25	22
Envelope stock	114	166	163	171	177	167	165	180	[a] 182
Gumming stock	165	222	178	173	181	128	93	110	111
Twisting and spinning stock (18-lb and up)	50	49	32	25	24	24	31	26	22
Waxing stock (18-lb and up)	41	48	53	43	47	43	26	30	26
Other converting	368	560	516	532	570	648	615	627	[a] 624
Total unbleached kraft	1,093	1,407	1,276	1,274	1,308	1,329	1,325	1,380	1,415
Other coarse converting paper:									
Envelope stock	171	174	159	183	187	168	215	264	[a] 257
Gumming stock	20	19	20	28	29	29	29	27	24
Twisting and spinning stock	14	24	26	22	21	25	27	20	19
Waxing stock (18-lb and up)	381	370	358	369	363	363	342	330	[a] 313
Cup stock (under 90-lb)	60	64	66	63	77	86	82	78	98
Other, such as asphalting, creping stock, etc	271	283	254	283	309	317	285	310	298
Total—other coarse converting	917	934	883	948	986	967	968	1,023	1,009
Total—converting paper	2,010	2,341	2,159	2,222	2,294	2,296	2,293	2,403	2,424

[a] Adjusted by Midwest Research Institute.

Source: U.S. Department of Commerce, Bureau of the Census. Pulp, paper, and board. *Current Industrial Reports*, Series M26A (59-13)—M26A(66-13). Washington, D.C., 1960-1967.

lene, lacquers, hot-melts, resin emulsions, and asphalts. They may be laminated to other kraft grades or to aluminum foil or glassine.

Wrapping papers are generally used for wrapping from roll stock by machinery and wrapping from rolls or precut sheets by hand. A great deal of wrapping paper is used to wrap industrial products such as lumber, roofing shingles, and steel; and food products, such as meats and frozen foods, in the store. Because wrapping papers are strong, they are sometimes used in making paper cans, tubes, and other containers.

It is likely that plastic will replace many of the currently used coatings and laminating materials. Polyethylene is replacing wax and asphalt as a coating material because it offers better crease resistance, heat seal characteristics, and good moisture and grease barrier properties. Widespread use of the paper bundling technique of wrapping would mean an increased use of wrapping paper. However, the future of this technique is not yet certain.

The volume of wrapping papers increased slightly from 1.1 billion pounds in 1958 to 1.2 billion pounds in 1966. The growth rate should remain modest because of competition from plastics and the decline of hand wrapping. A growth rate of 2 percent a year, yielding a 1976 volume of 1.5 billion pounds, is forecast for this product grouping.

Shipping Sacks

The shipping sack grade is used to make shipping sacks primarily to carry powdered or granular products, such as fertilizers, cement, carbon black, feeds, mulches, and the like. Shipping sacks are multiwalled, with at least three plies, and are designed to carry a minimum of 25 pounds. About 30 percent of all shipping sacks are made of extensible kraft paper, which enables the sacks to withstand stress more effectively than regular kraft papers.

Plastics and various forms of bulk packaging have been competing for the markets traditionally held by shipping sacks. In response to the use of all-plastic sacks for some products, many shipping sacks now combine kraft paper with other kinds of paper, plastics, or textiles. Paper sacks combined with plastic as a coating, lamination, or liner, offer toughness and moisture resistance.

In addition, shipping sacks are in competition with other packaging configurations such as barrels and pallet bins; the latter are often used to ship larger quantities than can be shipped in sacks, or in place of sacks because they are easier to handle. Shipping sack manufacturers have responded by developing a sack with a squared end that makes the sack easier to handle and to store and enables it to be placed on a pallet. Recently, a 30-cubic-foot paper sack that could hold 1,700 pounds was developed. This "jumbo" sack can be handled by forklift and may be useful in bulk shipments if the paper handling equipment is available.

Shipping sack closures have also undergone changes. Formerly, shipping sacks were sewn closed, with the consequence that they were difficult to open and reclose. Now, many bags have built-in valves or open mouths that can be sealed shut, opened, and resealed. In addition to easy-open features, many bags now have handles that make it convenient for customers to carry.

For the period 1958 to 1966 the volume of paper for shipping sacks increased slowly, about 2 percent a year. Because of the increased competition from plastics and other forms of bulk packaging, this rate will be even slower in the period up to 1976. Our forecast is for a growth rate of about 1 percent, from a volume of nearly 2.0 billion pounds in 1966 to a volume of 2.2 billion pounds in 1976.

Glassine, Greaseproof, and Vegetable Paper

Glassine, greaseproof, and vegetable papers are among the oldest types of packaging materials. Glassine is a transparent super-calendared paper with a smooth surface and high density. Greaseproof has been treated during the papermaking process to make it resistant to grease, fats, and oils. Vegetable paper has been treated with sulfuric acid to make it tough, dense, and highly greaseproof.

Glassine, greaseproof, and vegetable papers are used primarily in food packaging. These papers may be plain, or they may be coated with wax or lacquer when additional resistance to moisture, odors, or gas is necessary. They are used as pouches, bags, wraps, and envelopes for such food products as snack foods, cake mixes, baked goods, candy bars, and butter. These papers are also used as package liners, dividers, and inserts for meat products, cereals, cookies, candy, and the like.

Here as in other areas, plastic films are competing with glassine, greaseproof, and vegetable papers. However, flexible papers are gaining in such new applications as liners for baked goods packages, refrigerated dough tubes, motor oil cans, and cooking pouches. Glassine, greaseproof, and vegetable papers will be important packaging materials for some of the new food products that continue to be introduced—prepared mixes, powders, and dehydrated foods. These papers may also be used for highly specialized applications, such as wrapping of pre-greased mechanical parts.

In the future, glassine, greaseproof, and vegetable papers will continue to be important food packaging materials, especially in those cases where barriers to grease, odors, moisture, and gases are important. Because they are adaptable to many new uses, especially consumer food products, their use will continue to grow. We forecast a growth rate of approximately 2 percent a year, from 434 million pounds in 1966 to 520 million pounds in 1976.

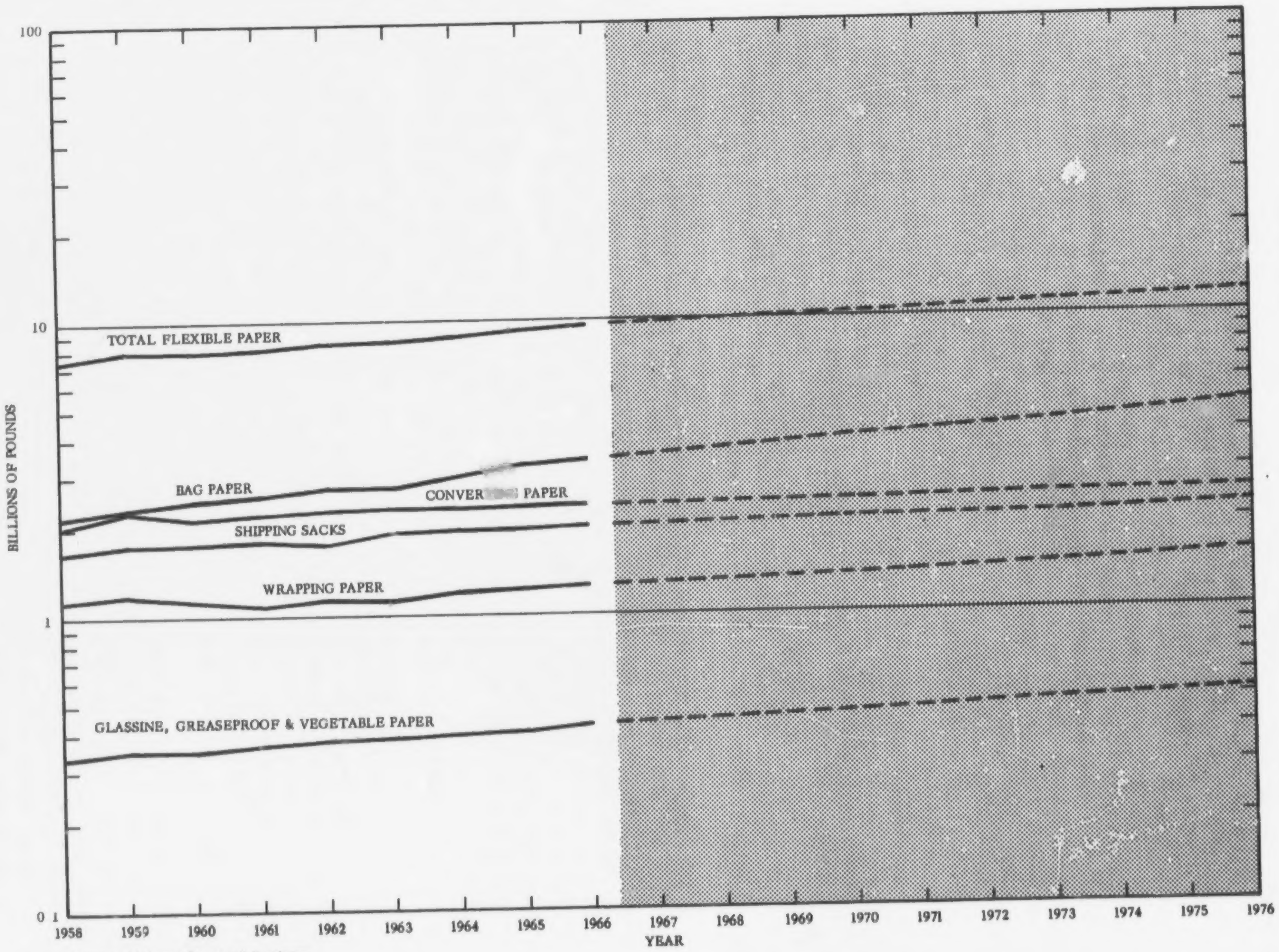
Flexible Papers—Summary Outlook

The flexible papers category of packaging materials will have an overall growth rate of 2.2 percent until 1976. Bag paper will have the highest growth rate in the group—4.1 percent, while converting paper will have the lowest at 0.3 percent a year (Table 18 and Figure 6).

TABLE 18.—*Production of flexible packaging papers by type: 1966 and 1976*

Flexible paper type	Millions of pounds		Ten-year rate of change (percent)
	Actual—1966	Forecast—1976	
Wrapping paper	1, 244	1, 520	2. 0
Shipping sack	1, 984	2, 240	1. 2
Bag paper	3, 358	5, 000	4. 1
Converting paper	2, 424	2, 500	. 3
Glassine, greaseproof, and vegetable paper	424	520	2. 0
Total	9, 434	11, 780	2. 2

Source: Midwest Research Institute.



Source: Midwest Research Institute

FIGURE 6.—Consumption of flexible paper in packaging: 1958–1976 (billions of pounds)

Specialty Paper

Specialty papers* include coated converting paper (one side); uncoated converting paper (book paper); tissue paper; and pressed and molded pulp. These papers have limited or specialized applications in packaging and are of lesser importance, from a volume standpoint, than the other paper and paperboard categories.

Coated Converting Paper (One Side)

Coated converting papers are relatively inexpensive, easily convertible, and, when printed, have an attractive appearance. These papers are not strong and are not used to protect the product. Printed can labels, gummed labels, printed outer wraps, and cover papers are the principal application for coated converting stock. These papers are also commonly foil-laminated to provide moisture control for certain products, for example, cigarette wraps.

New coatings and coating techniques, new adhesives, and advances in printing methods are being developed, although at present these developments are of relatively minor importance.

Uncoated Converting Paper (Book Paper)

Uncoated converting paper is usually of a finer grade than coated stock. Most uncoated converting papers end up as books, magazines, and writing tablets. However, about 20 percent of the book paper goes into packaging applications. Of the proportion used in packaging, about 75 percent is used for envelopes. These uncoated papers may be coated and then used in ways similar to coated converting paper. Consumption for packaging uses was 1.1 billion pounds in 1966 and will increse to 1.4 billion pounds in 1976.

Tissue Paper

Tissue is a lightweight paper made from pulp, with either a hard or soft surface finish. Some tissue paper is impregnated with resins or chemicals to inhibit tarnish, corrosion, and the action of fungi or bacteria.

Tissue paper has limited uses. It is used primarily as an inner wrap for such items as hosiery, flowers, silver, and candy. Tissue paper is also used for in-store packing to cushion clothing and to protect fragile goods. In industrial applications, it is used to form protective layers between sheets of glass, metal, plastic, linoleum, and the like. About one-third of all tissue paper is used as stock for wax tissue paper (Table 19).

Tissue is most frequently used in hand packing or with semi-automatic packing machinery. These packing methods are becoming less important and are being replaced by more automated operations. Because tissue is soft and pliable, it is not easy to use on automated machinery. Waxed tissue paper is being replaced by other coated papers and plastic films. The volume of waxed tissue paper has declined from 215 million pounds in 1959 to 171 million pounds in 1966.

Tissue paper should continue to be used in considerable quantity, especially in those applications where its special characteristics are important. For example, tissue serves as an inexpensive protective material for silver and other environment-sensitive products. On the other hand, because tissue paper is not readily adaptable to many modern packing techniques and because of competition from other coated papers and plastics, there will be an overall decline in the use of tissue paper. We estimate this decline will take place at a rate of 1.6 percent a year; volume should go from 472 million pounds in 1966 to 400 million pounds in 1976.

Molded Pulp

Pulp can be molded into low-cost packaging shapes. It is made from unaltered wood fibers such as pulpwood or chips (sawmill waste) or secondary fibers such as waste newsprint. The resulting material is absorbent, has a low density, and can be formed into rigid pieces.

There are two basic forms of molded pulp products—plates and dishes, and packing containers. Plates and dishes are commonly used for pies, cakes, and other baked goods; food service trays; paper plates; meat and produce trays. Molded pulp packing containers are used for egg cartons, egg crate flats, fresh fruit trays, and inserts to hold fragile items such as fluorescent lights and electronic parts. Most molded pulp is made into egg cartons and meat and produce trays.

The technology of producing molded pulp packages is relatively stable. Molded pulp prod-

---

*Reliable end use data are not available for materials in this category; thus, this paper group could not be analyzed as completely as were others. The quantitative forecasts are based primarily on historical trends, modified by other factors where appropriate.

Table 19.—*Tissue paper production by end use: 1958 to 1965*

In millions of pounds

End use	1958	1959	1960	1961	1962	1963	1964	1965
Wrapping tissue	95	98	97	91	99	101	118	119
Waxing tissue stock	185	215	208	210	194	186	163	171
Twisting tissue stock	14	20	18	19	22	21	19	23
Fruit and vegetable wraps; pattern tissue stock	41	37	38	37	39	40	39	40
Creped wadding	58	70	66	60	63	58	62	62
Other, including salesbook tissue	47	52	53	52	54	66	61	60
Total tissue paper	440	492	480	469	471	472	462	475

Source: U.S. Department of Commerce, Bureau of the Census. Pulp, paper, and board. *Current Industrial Reports*, series M26A(59-13)—M26A (66-13). Washington, D.C., 1960-1967.

ucts are facing competition from plastic foams. Polystyrene foam meat trays, for example, accounted for about 15 percent of all meat trays in 1966, and this share is likely to increase. Polystyrene foam packing inserts and pads may also displace some molded pulp products. Molded pulp meat tray sales are also threatened by clear, rigid plastic meat containers. These competitive thrusts, however, should be limited by the low cost of molded pulp and its excellent protective and absorbency characteristics. At the same time, while losing some markets to plastics, molded pulp products are gaining ground in certain types of industrial packaging, such as in packing sensitive electronic parts. All together, growth of this material should continue at a modest rate—2.2 percent annually. Production will grow from 481 million pounds in 1966 to 600 million pounds in 1976.

Specialty Paper—Summary Outlook

As a group, the specialty papers will maintain a modest 10-year growth rate of 2.6 percent. Coated converting paper will be the leader with a growth rate of 4.5 percent. Only one material—tissue paper—will have a declining growth rate (Table 20 and Figure 7).

GLASS

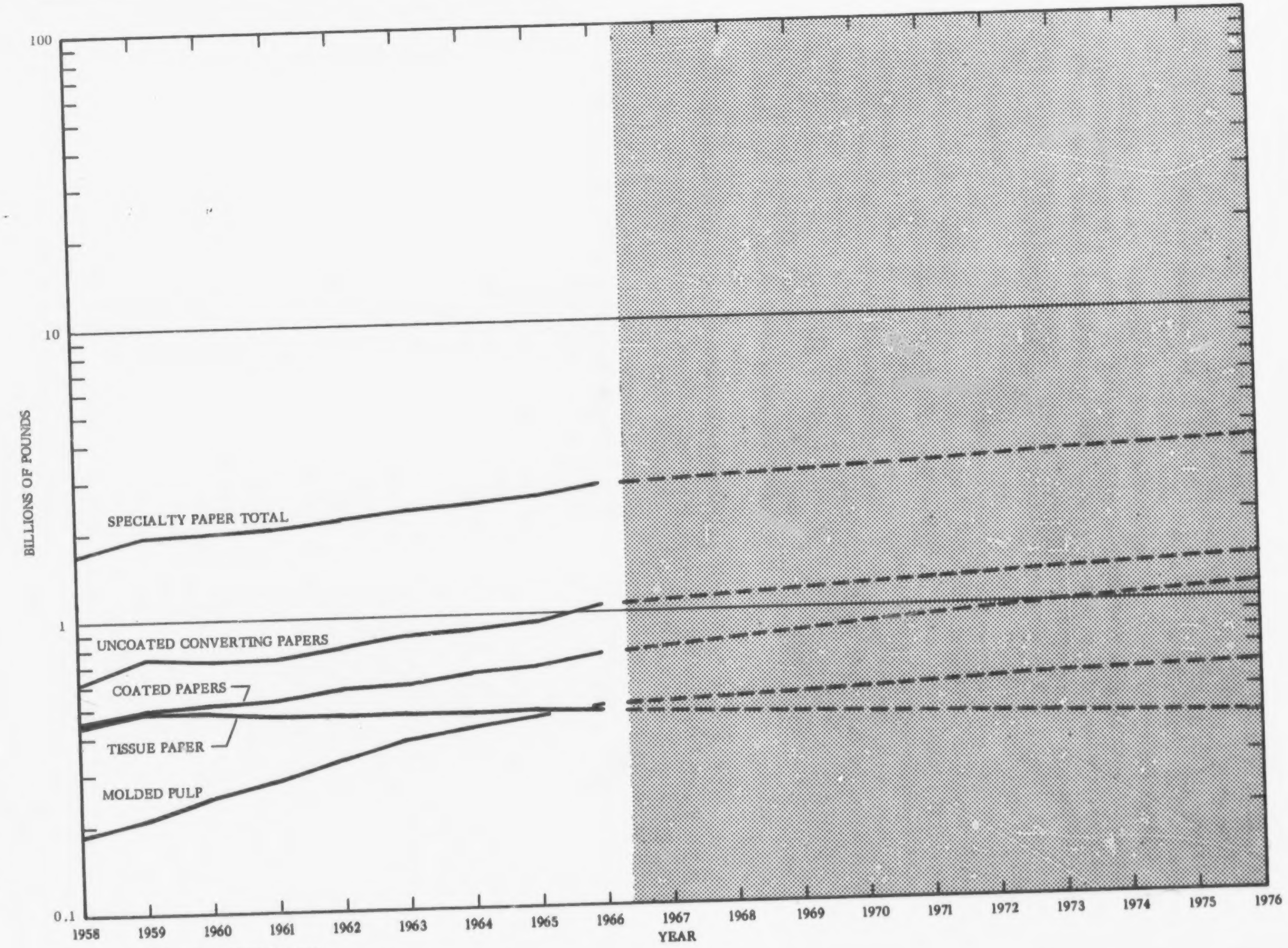
Along with wood and textiles, glass is one of the oldest container materials, tracing its history to the early civilizations. Glass makes a strong container with high gloss and transparency. It is chemically inert and an absolute barrier against all external influences except temperature and light. Foodstuffs which come in contact with glass do not take on an offtaste, which has made glass a favorite in food packaging. Glass containers can be made cheaply with automatic bottle making equipment which became available in the early part of this century.

Shipments of glass containers have been growing steadily in the period of this forecast, from 20.2 billion units in 1958 to 29.4 billion units in 1966. The basic trends in glass container usage indicate growth in coming years will continue along traditional lines in spite of competition from plastics and metals—with one major exception. Shipments of glass containers for beverages will more than double in the 1966 to 1976 period as nonreturnable glass containers come to replace the returnable bottle in soft drinks and beer. The radical change in this one container application prompts us to devote a separate section to beverage containers which will be presented under this heading but is also important for understanding trends in metal container usage.

Table 20.—*Production of specialty packaging papers by type: 1966 and 1976*

Specialty paper—type	Millions of pounds: Actual—1966	Millions of pounds: Forecast—1976	Ten-year rate of change (percent)
Coated converting paper (one side)	732	1, 140	4. 5
Uncoated converting paper (book paper)	1, 066	1, 430	3. 0
Tissue paper	472	400	—1. 6
Pulp, pressed and molded	481	600	2. 2
Total	2, 751	3, 570	2. 6

Source: Midwest Research Institute.



Source: Midwest Research Institute

FIGURE 7.—Consumption of specialty papers in packaging: 1958–1976 (billions of pounds)

Of the 29.4 billion units used in 1966 food products accounted for 10.8 billion units, beverages for 12.0 billion, drugs and cosmetics for 5.8 billion and industrial and household chemicals for 0.8 billion. Of these, 2.7 billion units were returnable beer, soft drink, and milk containers. Each of the returnable containers will make about 19 trips to the market on the average during its useful life of slightly over one year. In total, glass containers made 71.8 billion trips to the market place in 1966. Of this total 26.7 billion trips were made by nonreturnable containers and 45.1 billion trips were made by returnable containers. Thus if it were not for the returnable container, glass container requirements would have been 71.8 billion units in 1966. This illustrates the tremendous service performed by returnable bottles in keeping glass out of waste, despite their small share of total new units (under 10 percent). It also shows the huge potential market which glass makers see when they contemplate replacing returnable bottles with throw-away types.

Glass containers can be classified broadly into two groups—narrow neck and wide mouth. Bottles and jugs are defined by the first term; jars and tumblers by the second. On a unit basis, narrow neck containers are by far the more important.

Technological Trends

Glass is both fragile and a relatively heavy material. The breakable nature of glass is one of its severest limitations, for this requires that bottles be processed more slowly on filling lines than metal, requires more care and cushioning in shipment, and, in the case of returnable containers, has an effect on the life of the container. Weight of the glass package is a demerit because shipping costs tend to be high and tend to offset the material cost advantage which glass enjoys over materials with comparable performance characteristics.

In view of these facts, glass technology has been directed toward the creation of stronger and lighter containers. During the past 20 years, glass makers have slowly but certainly advanced toward the ideal container (from the packaging point of view)—the unbreakable and feather-light bottle. Bottle weight has declined by a third during the past two decades, and new glass coatings have made bottles more durable.

Weight of the container and its strength are, of course, related. More than 90 percent of the strength of glass is in the surface layer; consequently, reduction in breakage can be accomplished in one of two ways—by increasing the thickness of the container (which accounts for 10 percent of a bottle's strength) or by increasing the strength of the surface and its resistance to scratching and impacts. The present thrust of glass industry research is in the latter direction, because improvement of the surface strength can mean reduction of bottle thickness—which in turn means a lighter container that can be shipped at lower cost.

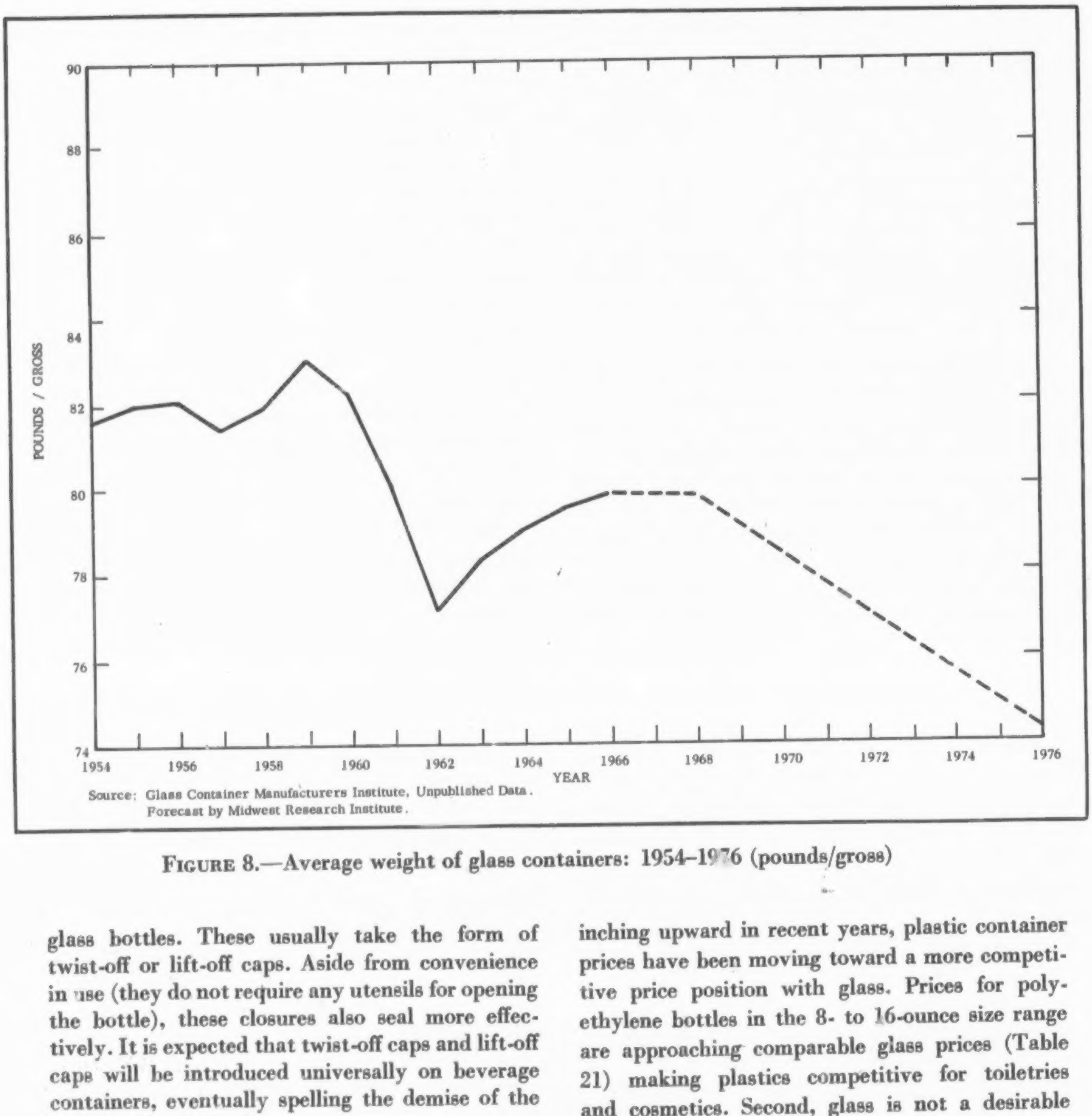
New ways to crystallize and arrange molecules on the surface layer and new surface treatments (e.g., with metallic oxide while the container is hot, polyethylene after it has cooled) are presently helping to make bottles stronger and lighter. Unit weight of glass containers is expected to decline,* as a consequence (Figure 8); handling speeds are expected to increase; and the thickness of materials used to cushion glass containers, for example, protective separating materials such as corrugated sheets, should decline.

Rapid technological change is also taking place in glass decoration, an important area for making glass a more attractive and competitive material in an innovation-hungry market environment. Direct decoration is becoming more widespread in this technique, enamel is fused onto the glass surface directly. New organic coatings have been developed which fuse at low temperatures; they are expected to have a wide impact, particularly on nonreturnable beverage containers, making it possible to differentiate such bottles more adequately. A relatively new process also permits glass coloring in small batches.

Another area of development is in closures. In a market that rewards convenience features, glass container manufacturers have met the challenge of pop-top beverage can closures by developing new closures of their own. Consequently, easy-open features are now being introduced in

---

*Average size of all glass containers and complexity of shape contribute significantly to average weight per unit. Technological advances, therefore, guarantee continued average-weight decline only if there is no significant change in the size mix and configurations now in common use.



Source: Glass Container Manufacturers Institute, Unpublished Data.
Forecast by Midwest Research Institute.

FIGURE 8.—Average weight of glass containers: 1954–1976 (pounds/gross)

glass bottles. These usually take the form of twist-off or lift-off caps. Aside from convenience in use (they do not require any utensils for opening the bottle), these closures also seal more effectively. It is expected that twist-off caps and lift-off caps will be introduced universally on beverage containers, eventually spelling the demise of the traditional metal crown.

Competitive Trends

Glass faces serious competition from metals and plastics in all of its traditional markets. Metals will be particularly strong contenders for beverage markets; and while they will not grow as rapidly as glass, they will limit the potential growth of glass bottles.

In competing with glass, plastics are favored by two factors. First, while glass prices have been inching upward in recent years, plastic container prices have been moving toward a more competitive price position with glass. Prices for polyethylene bottles in the 8- to 16-ounce size range are approaching comparable glass prices (Table 21) making plastics competitive for toiletries and cosmetics. Second, glass is not a desirable container material in the homemaker's view for products used in the bathroom or laundry. She is inclined to select household chemicals and toiletries packaged in plastics because plastic containers do not break. The appearance of clear polyvinyl chloride (PVC), and its approval for food packaging, will result in strong plastics competition for food containers that are presently of glass. In this area, however, glass enjoys an

Table 21.—*Typical 1967 prices of glass and plastic bottles for toiletries and cosmetics* [a]

Capacity and type of bottle	Price per 1,000 units	
	Glass	Plastic [b]
4-Ounce Boston-round [c]	$43. 54	$51. 17
8-Ounce Boston-round	54. 67	56. 87
16-Ounce Boston-round	78. 89	79. 96

[a] Small-order prices; large orders are discounted up to 30 percent.
[b] High density polyethylene.
[c] A common bottle style with rounded shoulder areas and narrow neck.

Source: *Modern Packaging*, 40(11): 177–180, July 1967.

"image" advantage: the homemaker views glass as a natural container for food products.

Glass and paper competition for liquids packaging is almost over. Wax- and now plastic-coated paper cartons have assumed dominance of the milk packaging market. Glass containers still make over five billion trips per year to homes carrying milk, but the outlook for glass in milk packaging is dim. Paper, and now plastic bottles, will continue to nibble away at the remaining glass markets in milk in continuation of an histortic trend (Table 22).

While its competition with paper milk containers has been one-sided, glass has scored well in its battle with metals, capturing the baby food market, powdered coffee, spice jars, and a variety of new instant food packaging applications which have been or could have been held by steel.

Outlook for Nonbeverage Glass Containers

Food

On the basis of the foregoing, we anticipate an increase of glass container shipments for foods from 10.8 billion units in 1966 to 12.7 billion units in 1976. This growth rate of 1.7 percent per year compares with a rate of 2.6 percent in the period 1958 to 1966. The decline in the growth rate is projected because we expect plastics to make a strong showing in such applications as the packaging of vegetable oil, vinegar, salad dressings, ketchup, juices, syrups, pickles, and peanut butter. All told, plastics should capture a market of at least 1.5 billion units from glass in these applications.

Drugs and Cosmetics

In 1966, 5.8 billion glass containers were shipped for drug and cosmetics packaging. Strong competition from plastics will result in completely eliminating the growth in this application area. By 1976, about the same number of containers (5.8 billion) will be shipped for packaging drugs and cosmetics as in 1966.

Chemicals

The decline in glass container consumption in industrial and household chemicals is already a well established trend. Between 1958 and 1966, glass lost 800 million units to other materials. We do not expect a turn-around in this area and estimate that by 1976, 400 million units will be produced and shipped for chemicals packaging, down from 800 million containers in 1966.

Historical data and projections are shown by end-use groupings (Tables 23 and 24). The tables also show glass container shipments for beverages, which are discussed in the next section. Figures 9 and 10 present these data graphically.

Outlook for Glass Beverage Containers

The most significant activity in glass containers must be sought in the area of beverage bottles where nonreturnable containers are gaining popularity rapidly at the expense of returnable bottles. By 1976, nonreturnable containers will have

Table 22.—*Milk container consumption and milk glass container fillings: 1958 to 1966*

In millions of units and fillings

Type of container	1958	1959	1960	1961	1962	1963	1964	1965	1966
Paperboard	14, 450	15, 032	15, 364	16, 158	18, 270	18, 214	18, 615	20, 232	21, 002
Glass (fillings)	10, 017	9, 550	8, 971	7, 835	5, 842	6, 206	6, 038	5, 926	5, 382
Plastic	0	0	0	0	0	([a])	([a])	45	74
Total	24, 467	24, 582	24, 335	23, 993	24, 112	24, 420	24, 653	26, 203	26, 458

[a] Not available.

Source: *Paperboard Packaging*, 52(8): 69, August 1967. U.S. Department of Commerce, Bureau of the Census. Closures for containers. *Current Industrial Reports*, Series M34H(59–13)—M34H(66–13). Washington, D.C., 1960–1967. U.S. Department of Commerce, Bureau of the Census. Plastic Bottles, *Current Industrial Reports*, Series M30E(65–13)—M30E(66–13). Washington, D.C., 1966–1967.

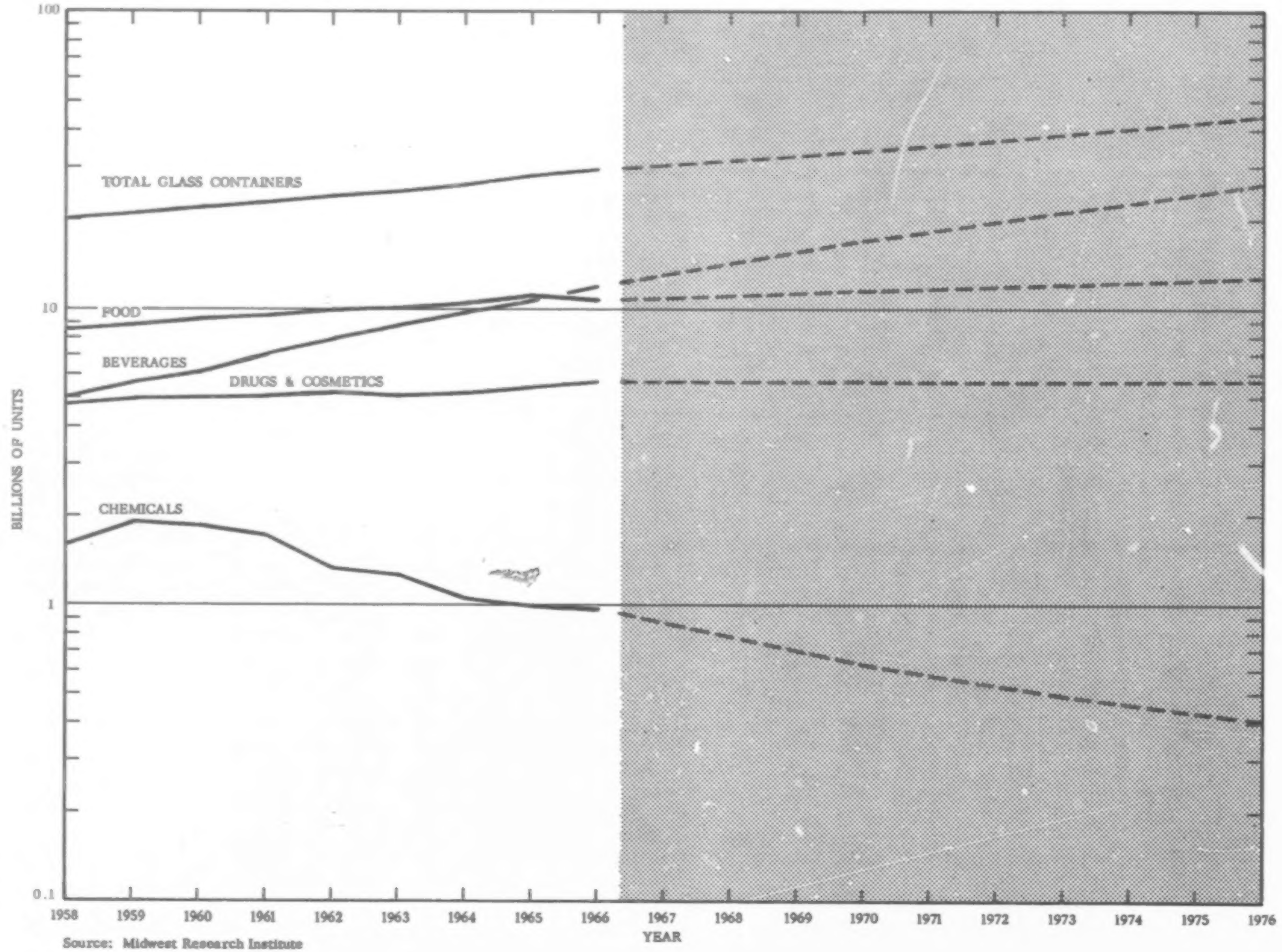
TABLE 23.—*Shipments of glass containers by end use: 1955 to 1976*

[In millions of units]

End use	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976
Food, total	8,051	8,167	8,395	8,669	8,998	9,189	9,584	10,068	10,072	10,508	11,024	10,754	11,500	12,100	12,730
Narrow neck	2,065	2,165	2,198	2,221	2,338	2,538	2,578	2,734	2,768	2,999	3,103	3,111	3,025	3,000	2,950
Wide mouth	5,584	5,627	5,870	6,171	6,373	6,389	6,760	7,102	7,085	7,304	7,739	7,479	8,350	9,000	9,700
Dairy	402	376	327	277	287	261	246	232	219	205	182	164	125	100	80
Beverage, total	4,905	5,178	4,989	5,073	5,703	6,180	7,135	8,077	8,902	9,745	10,611	12,045	17,090	21,090	26,820
Wine	661	678	664	653	708	727	731	713	754	784	784	769	} 2,730	2,890	3,060
Liquor	1,335	1,457	1,365	1,361	1,504	1,420	1,500	1,539	1,577	1,629	1,703	1,766			
Beer, total	1,506	1,542	1,561	1,627	1,865	2,377	3,164	3,775	4,239	4,788	5,203	5,608	6,760	7,800	9,060
Beer returnable	352	357	337	388	435	431	375	353	388	415	503	577	530	490	460
Beer nonreturnable	1,154	1,185	1,223	1,239	1,430	1,946	2,790	3,421	3,851	4,373	4,700	5.631	6,230	7,310	8,600
Soft drink, total	1,403	1,501	1,401	1,432	1,627	1,656	1,740	2,051	2,332	2,544	2,921	3,902	7,600	10,400	14,700
Soft drink returnable	1,233	1,330	1,217	1,240	1,415	1,407	1,338	1,574	1,772	1,912	1,914	1,922	1,600	1,400	1,200
Soft drink nonreturnable	169	171	183	192	211	249	402	477	560	632	1,006	1,980	6,000	9,000	13,500
Drug and cosmetic, total	4,722	4,805	5,073	4,829	5,040	5,012	5,158	5,298	5,135	5,294	5,587	5,760	5,760	5,760	5,760
Medicinal and health	2,955	3,054	3,262	2,985	3,100	3,011	3,119	3,253	3,109	3,188	3,393	3,429	3,560	3,610	3,660
Toiletry and cosmetic	1,767	1,751	1,811	1,843	1,939	2,002	2,039	2,045	2,026	2,106	2,194	2,331	2,200	2,150	2,100
Chemical, household and industrial, total	1,686	1,710	1,767	1,658	1,925	1,893	1,740	1,358	1,278	1,061	991	837	630	500	400
Narrow neck	1,386	1,399	1,449	1,391	1,644	1,620	1,494	1,143	1,067	846	784	658	....	....	....
Wide mouth	301	311	318	267	281	273	246	216	210	214	207	179	....	....	....
Glass domestic shipments, total [a]	19,364	19,861	20,225	20,228	21,667	22,275	23,617	24,803	25,387	26,608	28,213	29,396	34,980	39,450	45,710

[a] Categories may not add to total due to rounding.

Sources: U.S. Department of Commerce, Bureau of the Census. Glass containers. *Current Industrial Reports*, Series M32G(56–13)—M32G(66–13). Washington, D.C., 1957–1967. Glass Container Manufacturers Institute, *Glass Containers—1966*. New York, July 1967. p. 40–49. Forecasts by Midwest Research Institute.



Source: Midwest Research Institute

FIGURE 9.—Glass container shipments by end use—food: 1958–1976 (billions of units)

TABLE 24.—*Distribution of glass container shipments by end use: 1958 to 1976*

Percent of total units

End use	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976
Food total [a]	42.9	41.5	41.3	40.5	40.6	39.7	39.5	39.1	36.7	32.9	30.7	27.9
Beverage, total	25.0	26.3	27.7	30.3	32.5	35.1	36.6	37.7	40.9	48.8	53.3	58.6
Wine	3.2	3.3	3.3	3.1	2.9	3.0	2.9	2.8	2.6	7.8	7.3	6.7
Liquor	6.7	6.9	6.4	6.4	6.2	6.2	6.1	6.0	6.0	...	...	...
Beer, total	8.0	8.6	10.6	13.4	15.2	16.7	18.0	18.5	19.1	19.3	19.7	19.8
Beer, returnable	1.9	2.0	1.9	1.6	1.4	1.5	1.6	1.8	2.0	1.5	1.2	1.0
Beer, nonreturnable	6.1	6.6	8.7	11.8	13.8	15.2	16.4	16.7	17.1	17.8	18.5	18.8
Soft drink, total	7.1	7.5	7.4	7.4	8.2	9.2	9.6	10.4	13.2	21.7	26.3	32.1
Soft drink, returnable	6.1	6.5	6.3	5.7	6.3	7.0	7.2	6.8	6.5	4.6	3.5	2.6
Soft drink, nonreturnable	1.0	1.0	1.1	1.7	1.9	2.2	2.4	3.6	6.7	17.1	22.8	29.5
Drug and cosmetic, total	23.9	23.3	22.5	21.8	21.4	20.2	19.9	19.7	19.6	16.5	14.7	12.6
Medicinal and health	14.8	14.3	13.5	13.2	13.1	12.2	12.0	12.0	11.7	10.2	9.2	8.0
Toiletry and cosmetic	9.1	9.0	9.0	8.6	8.3	8.0	7.9	7.7	7.9	6.3	5.5	4.6
Chemical, household and industrial	8.2	8.9	8.5	7.4	5.5	5.0	4.0	3.5	2.8	1.8	1.3	0.9

[a] Includes dairy products.

Source: U.S. Department of Commerce, Bureau of the Census. "Glass Containers." *Current Industrial Reports*, Series M32G, 1958 to 1966. U.S. Government Printing Office, Washington. Forecasts by Midwest Research, Institute. Table 23.

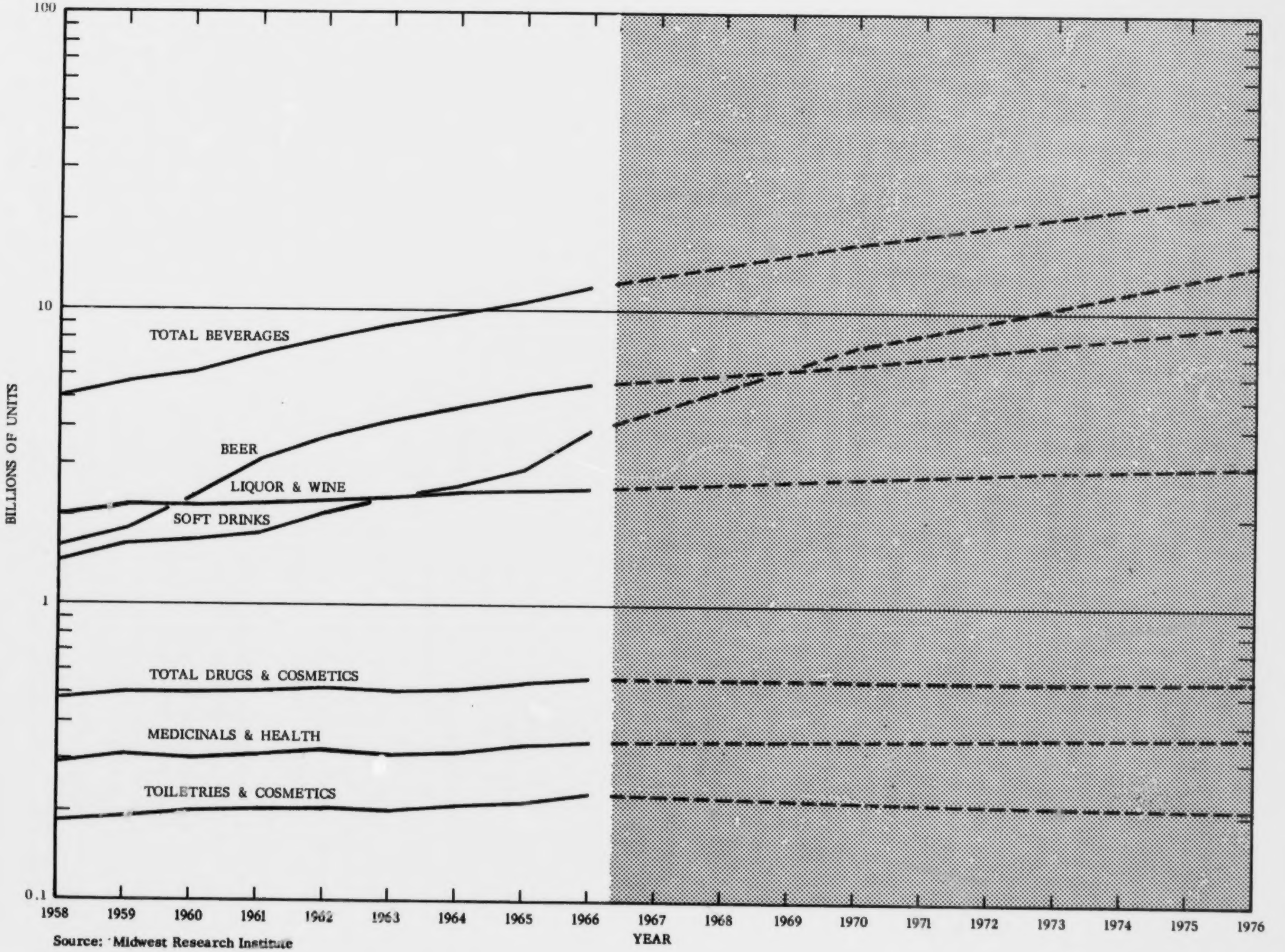
virtually replaced the deposit type bottle; and since each returnable bottle makes about 19 round trips before it is retired, each returnable bottle eliminated means the production of 19 nonreturnable containers, either glass or metal.

Three factors are bringing about the switch to nonreturnable containers: (1) the consumer's preference for a container which need not be returned to the retail establishment; (2) the retailer's disinclination to handle returnable bottles; and (3) the packaging material manufacturer's desire to exploit the potential of the beverage container market to the fullest.

The first two of these factors are the result of a desire for convenience which is difficult to quantify; the third factor can be measured more readily. In 1966, beer and soft drinks accounted for 65 billion fillings. However, in the same year, only about 26 billion beer and soft drink containers (glass and metal combined) were manufactured (see Table 25, p. 41). On the average, in other words, every container was filled twice. From the manufacturer's point of view, consequently, a potential market for 35 billion containers existed in 1966, which could have been achieved if no-return containers had been used exclusively. This is readily apparent to both metal and glass manufacturers. Glass makers, however, have more at stake: their markets are being eroded by plastics in foods, drugs, toiletries, and in chemicals. For glass, the nonreturnable beverage bottle is a last major growth frontier.

Competition for the beverage packaging markets is extremely keen. All major materials—steel, aluminum, and glass—have distinct advantages and are comparable in final cost. Final cost, in this instance, would include all expenditures such as those for materials, forming, filling, packing, and shipment. Disposal costs, of course, are not included.

Metals, generally, are favored by convenience features: they are easy to open with pop-top closures; they are less bulky in storage; they are convenient to handle; their contents chill rapidly; and they lend themselves to flashy decoration. Cans are more expensive than bottles on a unit basis. However, they can be filled more rapidly and they enjoy an advantage in shipment be-



Source: Midwest Research Institute

FIGURE 10.—Glass container shipments by end use—beverages, drugs, and cosmetics: 1958–1976 (billions of units)

TABLE 24.—*Distribution of glass container shipments by end use: 1958 to 1976*

Percent of total units

End use	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976
Food total [a]	42.9	41.5	41.3	40.5	40.6	39.7	39.5	39.1	36.7	32.9	30.7	27.9
Beverage, total	25.0	26.3	27.7	30.3	32.5	35.1	36.6	37.7	40.9	48.8	53.3	58.6
Wine	3.2	3.3	3.3	3.1	2.9	3.0	2.9	2.8	2.6	7.8	7.3	6.7
Liquor	6.7	6.9	6.4	6.4	6.2	6.2	6.1	6.0	6.0	...	...	...
Beer, total	8.0	8.6	10.6	13.4	15.2	16.7	18.0	18.5	19.1	19.3	19.7	19.8
Beer, returnable	1.9	2.0	1.9	1.6	1.4	1.5	1.6	1.8	2.0	1.5	1.2	1.0
Beer, nonreturnable	6.1	6.6	8.7	11.8	13.8	15.2	16.4	16.7	17.1	17.8	18.5	18.8
Soft drink, total	7.1	7.5	7.4	7.4	8.2	9.2	9.6	10.4	13.2	21.7	26.3	32.1
Soft drink, returnable	6.1	6.5	6.3	5.7	6.3	7.0	7.2	6.8	6.5	4.6	3.5	2.6
Soft drink, nonreturnable	1.0	1.0	1.1	1.7	1.9	2.2	2.4	3.6	6.7	17.1	22.8	29.5
Drug and cosmetic, total	23.9	23.3	22.5	21.8	21.4	20.2	19.9	19.7	19.6	16.5	14.7	12.6
Medicine and health	14.8	14.3	13.5	13.2	13.1	12.2	12.0	12.0	11.7	10.2	9.2	8.0
Toiletry and cosmetic	9.1	9.0	9.0	8.6	8.3	8.0	7.9	7.7	7.9	6.3	5.5	4.6
Chemical, household and industrial	8.2	8.9	8.5	7.4	5.5	5.0	4.0	3.5	2.8	1.8	1.3	0.9

[a] Includes dairy products.

Source: U.S. Department of Commerce, Bureau of the Census. "Glass Containers." *Current Industrial Reports*, Series M32G, 1958 to 1966. U.S. Government Printing Office, Washington. Forecasts by Midwest Research, Institute. Table 23.

virtually replaced the deposit type bottle; and since each returnable bottle makes about 19 round trips before it is retired, each returnable bottle eliminated means the production of 19 nonreturnable containers, either glass or metal.

Three factors are bringing about the switch to nonreturnable containers: (1) the consumer's preference for a container which need not be returned to the retail establishment; (2) the retailer's disinclination to handle returnable bottles; and (3) the packaging material manufacturer's desire to exploit the potential of the beverage container market to the fullest.

The first two of these factors are the result of a desire for convenience which is difficult to quantify; the third factor can be measured more readily. In 1966, beer and soft drinks accounted for 65 billion fillings. However, in the same year, only about 26 billion beer and soft drink containers (glass and metal combined) were manufactured (see Table 25, p. 41). On the average, in other words, every container was filled twice. From the manufacturer's point of view, consequently, a potential market for 35 billion containers existed in 1966, which could have been achieved if no-return containers had been used exclusively. This is readily apparent to both metal and glass manufacturers. Glass makers, however, have more at stake: their markets are being eroded by plastics in foods, drugs, toiletries, and in chemicals. For glass, the nonreturnable beverage bottle is a last major growth frontier.

Competition for the beverage packaging markets is extremely keen. All major materials—steel, aluminum, and glass—have distinct advantages and are comparable in final cost. Final cost, in this instance, would include all expenditures such as those for materials, forming, filling, packing, and shipment. Disposal costs, of course, are not included.

Metals, generally, are favored by convenience features: they are easy to open with pop-top closures; they are less bulky in storage; they are convenient to handle; their contents chill rapidly; and they lend themselves to flashy decoration. Cans are more expensive than bottles on a unit basis. However, they can be filled more rapidly and they enjoy an advantage in shipment because of lower weight. For instance, a "thin-tin" can weighs about one-fifth as much as a comparable nonreturnable bottle.

Developments in glass technology are now removing certain disadvantages of glass in these markets. Twist-off and lift-off closures have been introduced. Lighter weight bottles are becoming available, aiding in the reduction of glass shipping costs. Stronger glass containers promise higher filling rates. Decoration technology in glass is improving, pointing to more attractive bottles. The greatest advantage of glass, however, is that in the consumer's view it is the traditional container for beverages.

Distinct differences between beer and soft drink packaging markets exist. Nonreturnable containers have been established in beer packaging for some time, while they are a relative newcomer in soft drinks as these shipment figures, given in billions of units, indicate:

	1958	1966	Increase in period (percent)
Nonreturnable beer containers....	9.6	18.0	88
Nonreturnable soft drink containers....	.6	7.6	1,163

During the same period of time, returnable container shipments have increased much more modestly, and the absolute quantities (in billions of units) are much lower:

	1958	1966	Increase in period (percent)
Returnable beer bottles..........	0.4	0.6	50
Returnable soft drink bottles......	1.2	1.9	58

It is well to remember, however, looking at returnable bottle figures, that each container represents about 19 trips to the market. Consequently, although low in overall number of units, returnable bottles represent many more fillings than nonreturnable containers.

All returnable beverage containers are glass. In the nonreturnable category, metal dominates. In 1966, of a total of 25.6 billion nonreturnable containers used for beer and soft drink packaging, 18.6 billion units, or 72 percent, were cans.

TABLE 25.—*Beer and soft drink container production by type of container and use: 1958, 1966, and 1976*

In millions of units

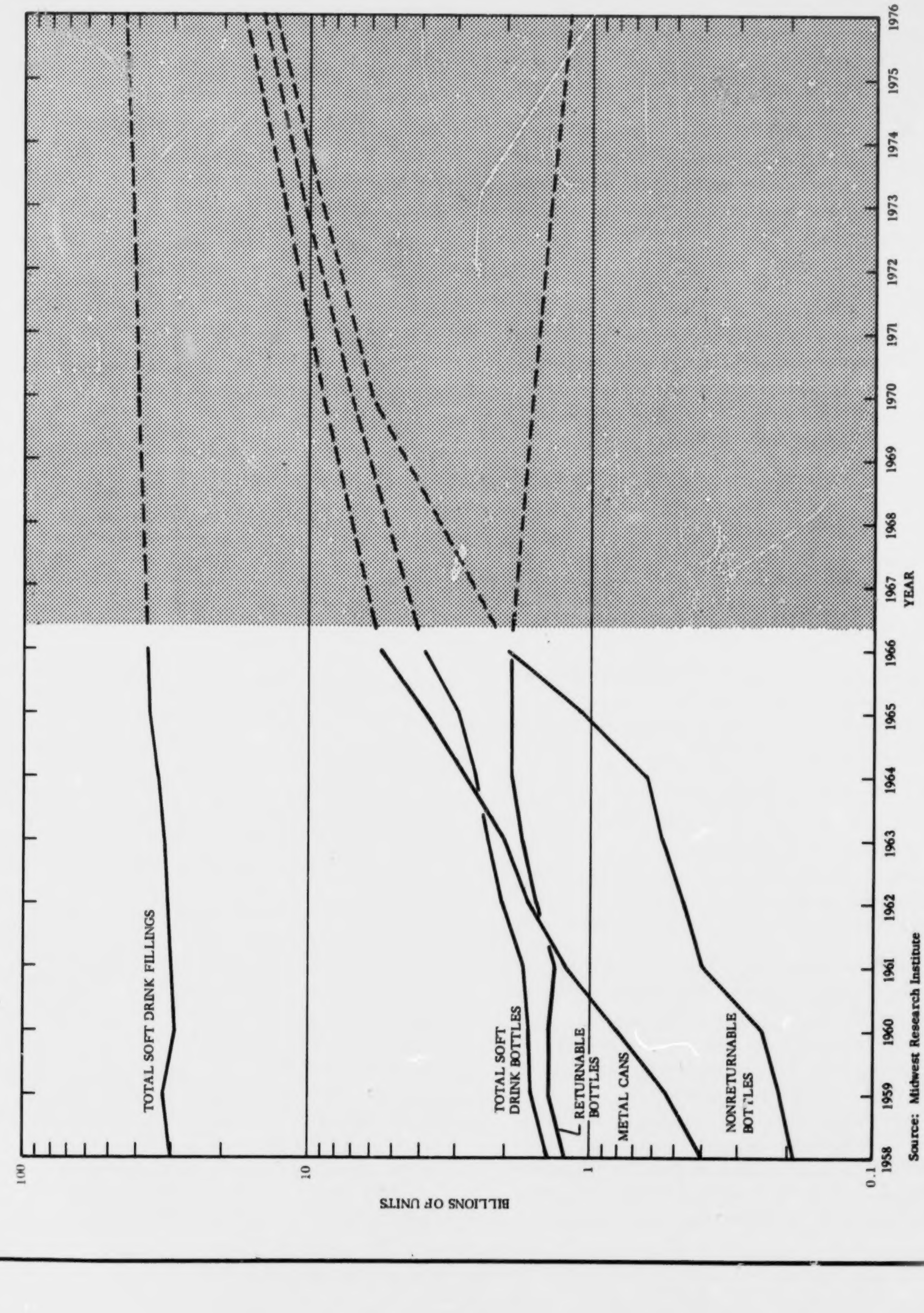
Type of container	1958	1966	1976
Nonreturnable containers:			
Bottles:			
Soft drink..........	192	1,980	13,500
Beer...............	1,239	5,031	8,600
Total............	1,431	7,011	22,100
Cans:			
Soft drink..........	409	5,612	17,000
Beer...............	8,337	12,947	19,000
Total............	8,746	18,559	36,000
Nonreturnable total.	10,177	25,570	58,100
Returnable containers:			
Soft drink..........	1,240	1,922	1,200
Beer...............	388	577	460
Returnable total..	1,628	2,499	1,660
Total containers.	11,805	28,069	59,760
Total fillings......	52,921	65,213	79,500
Ratio, containers to fillings...	1:4.48	1:2.32	1:1.33

Source: Table 23.

Looking toward 1976, we forecast the following changes in the beverage container market on the basis of our analysis of technological changes and consumption patterns:

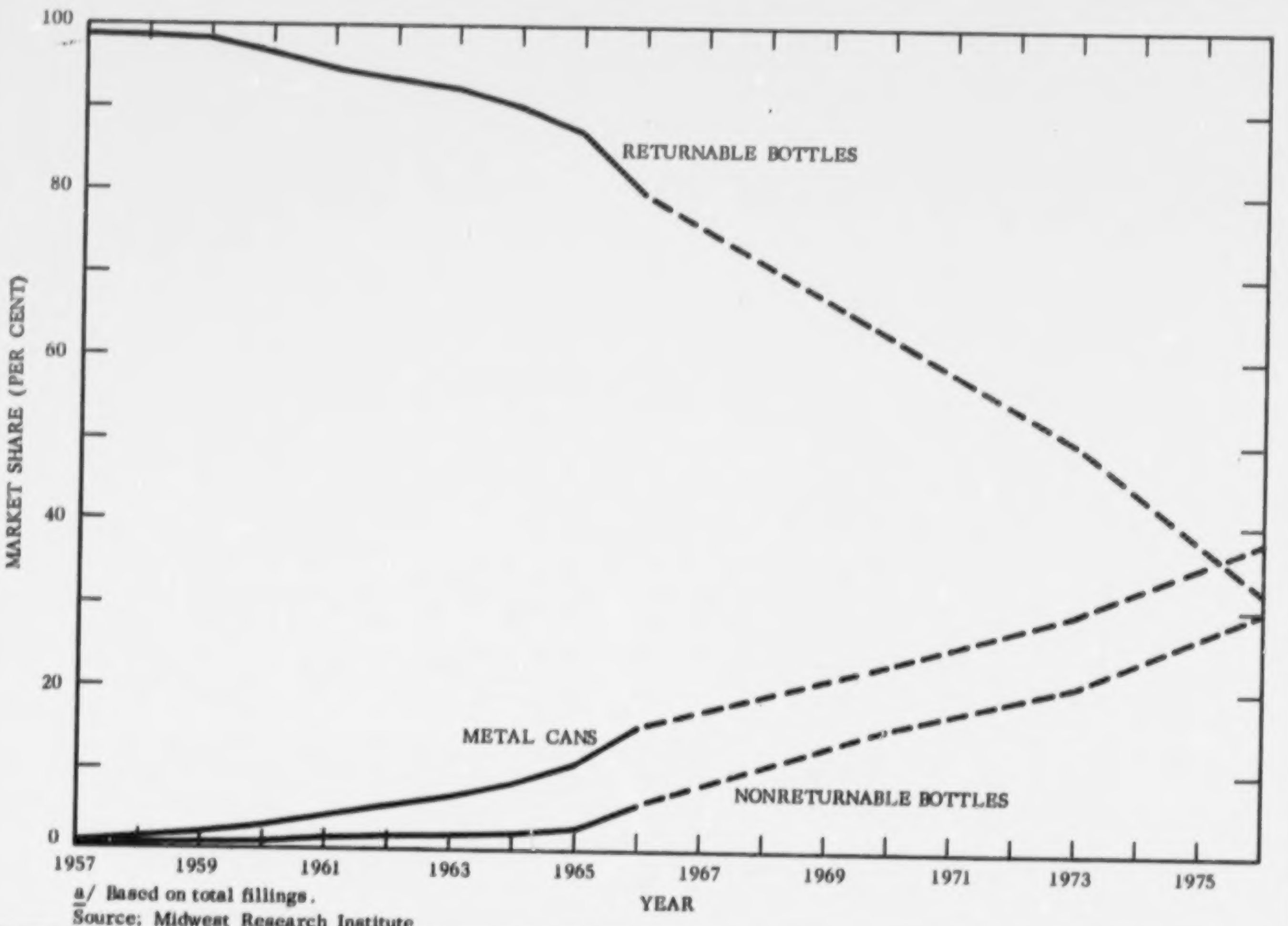
—Nonreturnable container production will increase from 25.6 billion units to 58.1 billion units, an increase of 127 percent in the period or an annual growth rate of 8.5 percent.

—Metal cans will still represent 72 percent of all nonreturnable beverage packaging in 1976, or 36 billion units. Glass will maintain its 1966 share of this market throughout the period, growing to 22.1 billion units in 1976. But since glass starts from a lower quantity base than metal cans, the growth rate of nondeposit glass bottles will be more vigorous (12.2 percent annually) than that enjoyed by metals (6.8 percent annually). Strong growth in glass is attributed, in this forecast, to recent technological improvements in the throw-away container



Source: Midwest Research Institute

FIGURE 11.—Shipments of soft drink containers: 1958–1976 (billions of units)



a/ Based on total fillings.
Source: Midwest Research Institute

FIGURE 12.—Soft drink containers by type: 1957–1976 (market share in percent)[a]

and the fact that glass enjoys an "image" advantage over metal in beverage packaging. Also, proprietary shapes (e.g., "Coke") in no returns are expected to make their appearance very soon.

—Nonreturnable metal beer and soft drink containers, as will be shown in the next section, is one of the major growth opportunities for aluminum in competition with steel containers.

—Returnable container consumption will decline, from 2.5 billion units in 1966 to 1.7 billion units 10 years later.

These data have been summarized for the years 1958, 1966, and 1976 (Table 25) and are presented in greater detail in Table 26. The source data are shown in graphic form (Figures 11 to 14).

Glass: Summary Outlook

On a unit basis, glass container shipments will grow at a rate of 4.5 percent annually in the 1966 to 1976 period, resulting in consumption of 45.7 billion containers in 1976, up from 29.4 billion units in 1966.

During this period, the average unit weight of glass containers will be declining. Consequently, calculated on a weight basis, the growth in glass will not be as great as unit increases. In 1966, the 29.4 billion glass containers weighed 16.5 billion pounds; by weight glass consumption will increase at a rate of 3.7 percent annually, resulting in 23.8 billion pounds of containers in 1976.

METALS

In 1966, 14.3 billion pounds of metals were converted into packages, making metals one of

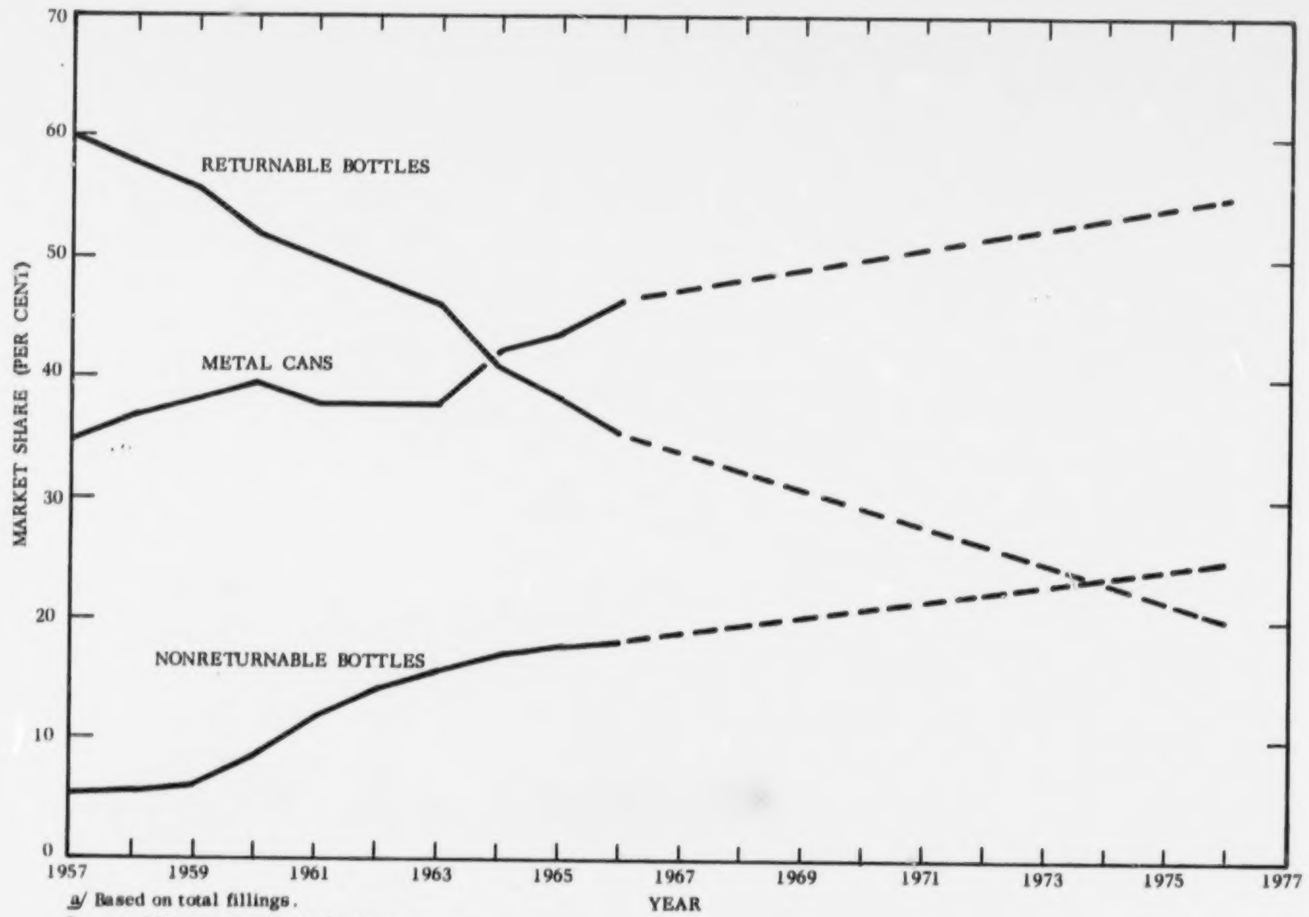
TABLE 26.—*Shipments of beer and soft drink containers: 1958 to 1967*

In millions of units

Type of container	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976	1966 to 1976 rate of change (percent)
Soft drink:													
Total crowns and cans (fillings)	30,262	32,228	29,299	30,754	31,232	32,264	34,384	36,993	37,564	40,100	42,500	45,000	1.8
Soft drink crowns	29,843	31,680	28,487	29,529	29,581	30,206	31,589	33,152	31,952	31,100	30,200	28,000	−1.3
Soft drink metal cans	409	548	812	1,225	1,651	2,058	2,795	3,841	5,612	9,000	12,300	17,000	11.8
Soft drink bottles	1,432	1,627	1,656	1,740	2,051	2,332	2,544	2,921	3,902	7,600	10,400	14,700	14.2
Returnable	1,240	1,415	1,407	1,338	1,574	1,772	1,912	1,914	1,922	1,600	1,400	1,200	−4.8
Nonreturnable	192	212	249	402	477	560	632	1,007	1,980	6,000	9,000	13,500	21.2
Market share (percent):													
Metal cans	1.4	1.7	2.8	4.0	5.3	6.4	8.1	10.4	14.9	22.5	29.0	37.8	....
Returnable bottles [a]	98.0	97.7	96.4	94.7	93.2	91.9	90.1	86.9	79.6	62.5	49.8	32.2	....
Nonreturnable bottles	.6	.6	.8	1.3	1.5	1.7	1.8	2.7	5.5	15.0	21.2	30.0	....
Beer:													
Total crowns and cans (fillings)	22,659	23,149	22,497	23,199	24,026	24,589	25,762	26,212	27,649	30,150	32,300	34,500	2.2
Beer bottle crowns	14,322	14,793	13,609	14,438	14,951	15,265	14,866	14,830	14,702	15,050	15,370	15,500	0.4
Beer cans	8,337	9,156	8,888	8,761	9,075	9,324	10,896	11,382	12,947	15,100	16,930	19,000	3.9
Beer bottles	1,627	1,865	2,377	3,164	3,775	4,239	4,788	5,203	5,608	6,760	7,800	9,060	4.9
Returnable	388	435	431	375	353	388	415	503	577	530	490	460	−2.2
Nonreturnable	1,239	1,430	1,946	2,789	3,422	3,851	4,373	4,700	5,031	6,230	7,310	8,600	5.5
Market share (percent):													
Metal cans	36.8	38.2	39.5	37.8	37.8	37.9	42.3	43.4	46.7	50.0	52.3	55.1	....
Returnable bottles [a]	57.7	55.6	51.8	50.2	48.0	46.4	40.7	38.7	35.1	29.3	25.1	20.0	....
Nonreturnable bottles	5.5	6.2	8.7	12.0	14.2	15.7	17.0	17.9	18.2	20.7	22.6	24.9	....

[a] Calculated as a percent of total fillings (not based on returnables produced any one year).

Source: U.S. Department of Commerce, Bureau of the Census. Glass containers, *Current Industrial Reports*, Series M32G(59–13)—M32G(66–13). Washington, D.C., 1960–1967. U.S. Department of Commerce, Bureau of the Census, Metal cans, *Current Industrial Reports*, Series M34–D(59–13)—M34D (66–13). Washington, D.C., 1960–1967. Class Container Manufacturers Institute, *Glass Containers—1966*. New York, 1967. Can Manufacturers Institute, *Annual Report—Metal Cans Shipments—1966*. Washington, D.C., 1967. Forecasts by Midwest Research Institute.



a/ Based on total fillings.
Source: Midwest Research Institute

FIGURE 13.—Beer containers by type: 1957–1976 (market share in percent) a

the major packaging materials. The overwhelming bulk of metals (nearly 75 percent) were converted into metal cans. These cans, made mostly of tin-coated steel stock and a small amount of aluminum, provided 54.4 billion packaging units.

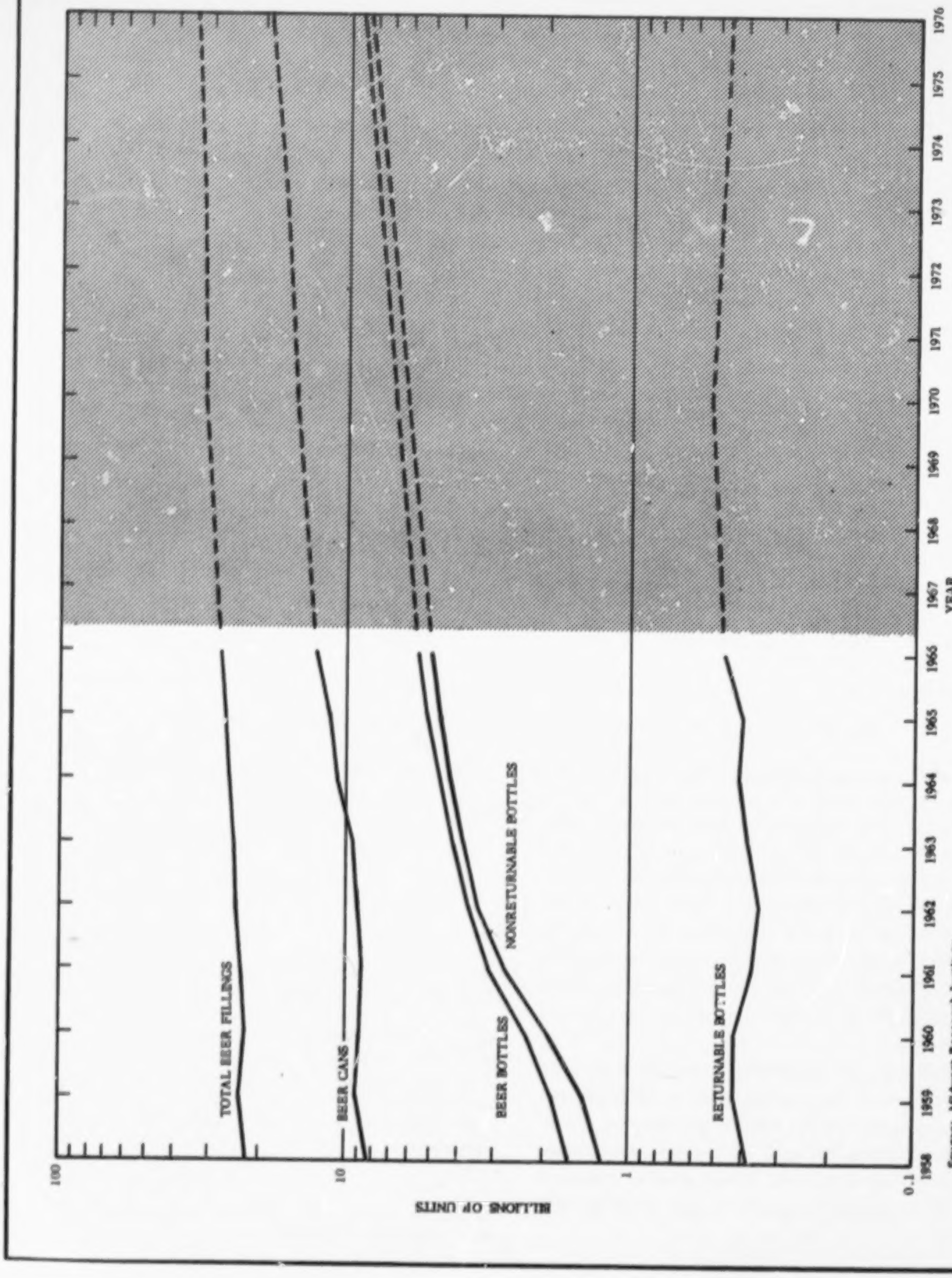
The remaining tonnage was distributed among six other configuration categories: (1) aluminum foil and semi-rigid containers; (2) collapsible metal tubes; (3) steel drums and pails; (4) metal strapping; (5) gas cylinders; and (6) metal caps and crowns.

A summary of quantities of metals that were used in each of these applications in 1966 and are expected to be used in 1976 is presented in Table 27 and Figures 15 and 16. Overall, we foresee growth in this area to be taking place at a modest rate of 1.6 percent annually in the 1966 to 1976 period.

TABLE 27.—*Consumption of metal packaging materials by type: 1966 and 1976*

Type	Quantity (millions of pounds)		Ten-year rate of change (percent)
	Actual—1966	Forecast—1976	
Steel cans	10, 348	11, 420	1. 0
Aluminum cans and ends	329	1, 400	15. 6
Collapsible metal tubes	32	25	−2. 4
Rigid aluminum foil containers	88	150	5. 5
Aluminum foil converted	266	465	5. 7
Steel drums and pails	1, 646	1, 560	−1. 5
Metal strapping	800	990	2. 2
Gas cylinders	120	120	0
Metal caps	263	320	2. 0
Metal crowns	412	380	−. 8
Total	14, 304	16, 830	1. 6

Source: Midwest Research Institute.



Source: Midwest Research Institute

FIGURE 14.—Shipments of beer containers: 1958–1976 (billions of units)

Each of the configurations mentioned above is found predominantly in either consumer or industrial markets:

Type	Predominantly consumer	Predominantly industrial
Steel and aluminum cans	X	....
Aluminum foil and semi-rigid containers	X	....
Collapsible metal tubes	X	....
Steel drums and pails		X
Metal strapping		X
Gas cylinders		X
Metal caps and crowns	X	....

About 90 percent of all metal packaging material, on a weight basis, is steel. Aluminum accounts for most of the rest, along with small amounts of lead, zinc, and tin. Aluminum plays a relatively minor role in packaging at present; this material, however, has been growing rapidly and can be expected to become significantly more important as a packaging material in the future.

All metals have one overriding advantage over any other kind of packaging material—their strength. Metal containers also protect their contents from the effects of heat, cold, moisture, rough handling, and light and lend themselves to attractive decoration.

Metal Cans

Metal cans are by far the most common type of metal package. In 1966, cans accounted for 75 percent of all metal packages by weight. They are used for more than 2,500 products by 135 industries. However, food and beverages are the products most often packaged in metal cans. These two outlets account for 84 percent of all cans produced. A summary of metal can production is provided in Table 28. Tables 29 and 30 show the same data in greater detail; Figures 17, 18, and 19 present the information graphically.

The dominance of cans for consumer packaging of food items may be illustrated by the following statistics:

—Americans purchase and consume the contents of more than 131 million cans in an average day;

—The average American family uses about 850 metal cans in a year; and

—The average American empties about 252 cans in a year, or almost five per week.

The most common and familiar metal can is the cylindrical, three-piece (wall and two ends), sanitary food can. However, there are other shapes—oval, oblong, and square. The cylindrical food container usually has both ends sealed, although many different kinds of closures—basically friction fit, key opening, and hinged lid—may be used on metal cans. Cans range in capacity from a few ounces to more than a gallon.

Most cans are made from steel. Available statistics on can production do not differentiate between steel and aluminum cans; consequently, aluminum cans will be discussed in this section.

TABLE 28.—*Consumption of metal cans by end use: 1958, 1966, and 1976*

In billion units

Can end use	1958	1966	Rate of change 1958 to 1966 (%)	1976	Rate of change 1966 to 1976 (%)
Foods[a]	25.6	26.2	0.3	29.0	1.0
Beverages	9.7	19.5	9.1	36.9	6.6
Nonfood	8.0	8.7	1.1	12.4	3.6
Total	43.3	54.4	2.9	78.3	3.7

[a] The food canning rate varies with fruit and vegetable crop yields.

Source: Can Manufacturers Institute. *Annual Report—Metal Can Shipments—1966.* Washington, D.C., 1967. Forecasts by Midwest Research Institute.

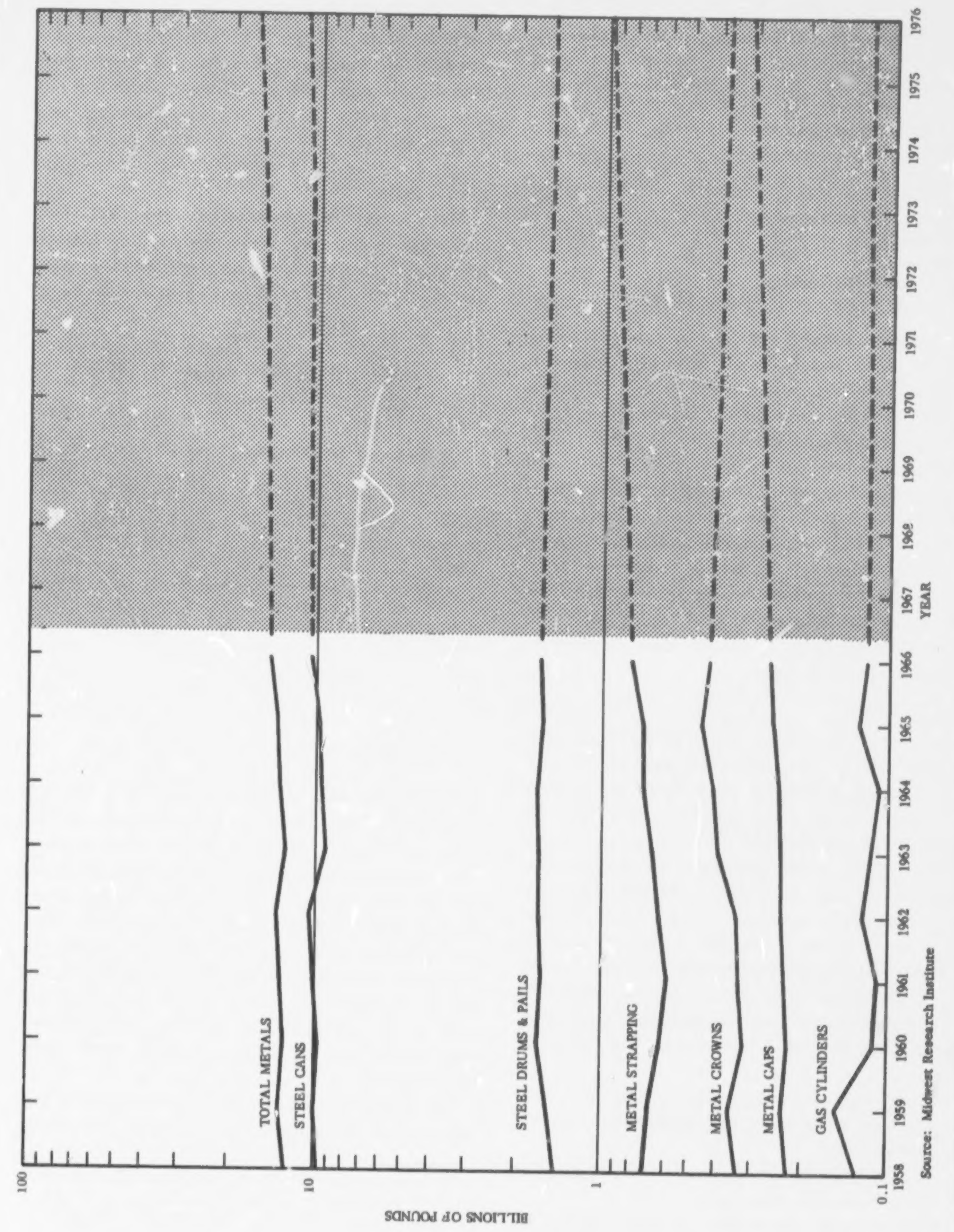
Aluminum

Aluminum cans are relative newcomers to the market. In 1966 aluminum accounted for only 4.6 percent of total base boxes* of can metal shipped. Aluminum containers are used primarily for beer, but some are used for soft drinks, frozen foods, canned meats, fish, pet foods, and aerosols. They are lightweight—between 39 and 45 pounds per base box compared with 55 pounds per base box for the lightest steel cans. Aluminum cans cost more than steel cans, but the weight differential and subsequent shipping savings offset their higher price.

Aluminum has many attractive features in this application. It is corrosion resistant and highly

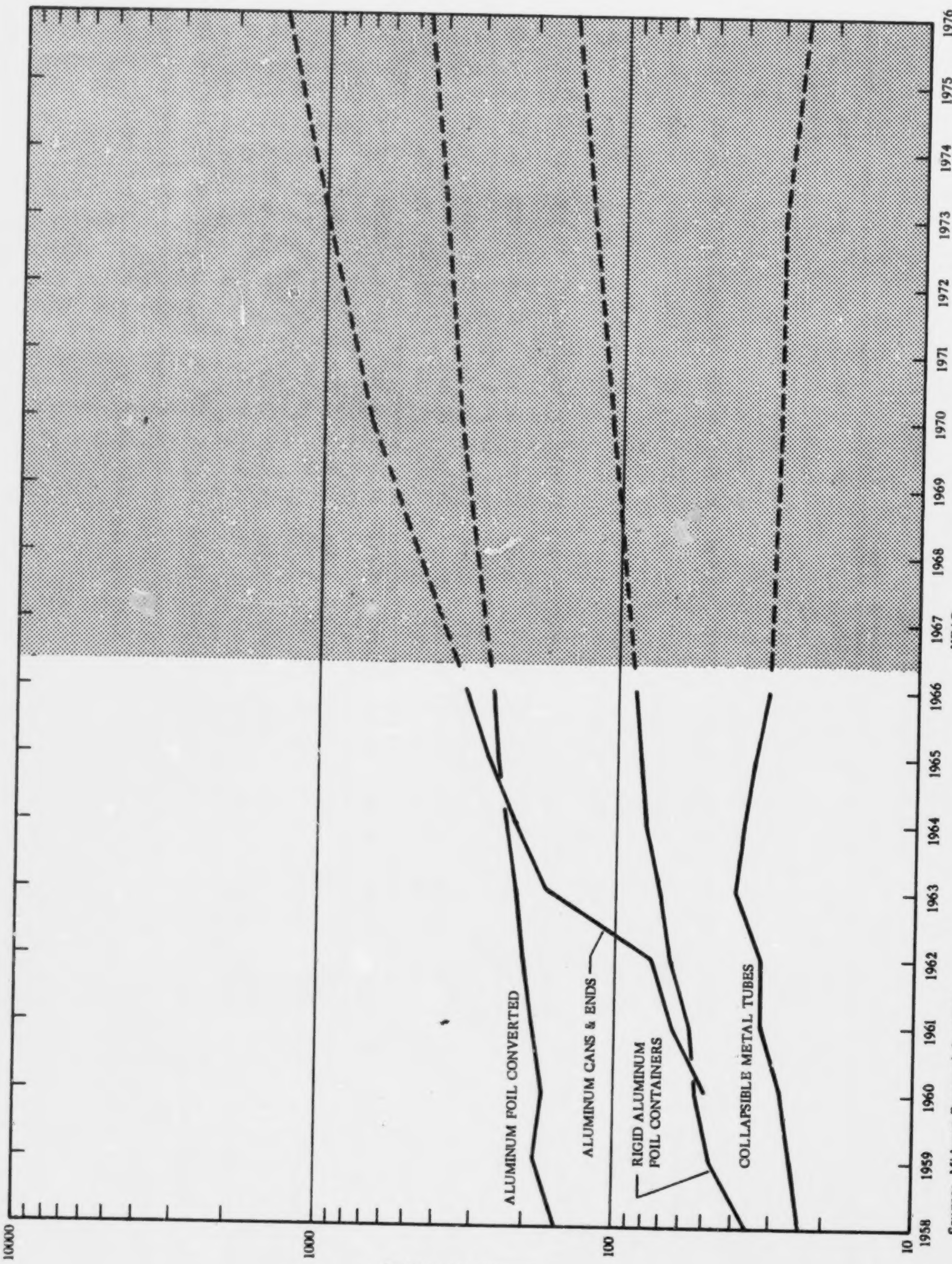
---

*A base box is the unit of measure used in can sheet stock. It is an area of 31,360 square inches, equivalent to 112 sheets 14 x 20 inches in size. About 500 12-ounce cans can be made from 1 base box.



Source: Midwest Research Institute

FIGURE 15.—Consumption of metal in packaging: 1958–1976 (billions of pounds)



Source: Midwest Research Institute

FIGURE 16.—Consumption of metal in packaging: 1958–1976 (millions of pounds)

TABLE 29.—*Shipments of metal cans by end use: 1958 to 1976*

Thousand base boxes

End use	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976	1966 to 1976 rate of change (%)
Food—beverage:													
Fruit and fruit juices, veg. and veg. juices	33, 384	33, 469	33, 555	34, 805	37, 081	32, 989	34, 914	35, 350	35, 982	37, 300	38, 300	39, 360	0. 9
Evaporated milk and other dairy products	5, 909	5, 709	5, 385	5, 256	4, 975	4, 768	4, 767	4, 329	4, 403	3, 900	3, 560	3, 250	—3. 0
Meat and poultry, fish and seafood	5, 803	5, 813	6, 064	6, 358	6, 565	6, 529	6, 713	6, 554	6, 844	7, 270	7, 600	7, 940	1. 5
Lard and shortening	2, 387	2, 322	1, 974	2, 256	2, 356	2, 071	2, 053	1, 906	1, 842	1, 570	1, 380	1, 230	—4. 0
Baby food and formulae, all other foods	11, 362	11, 638	12, 397	12, 643	12, 795	12, 926	13, 615	14, 181	14, 661	16, 180	17, 430	18, 770	2. 5
Total foods	58, 845	58, 951	59, 375	61, 318	63, 772	59, 283	62, 062	62, 320	63, 732	66, 220	68, 270	70, 550	1. 0
Coffee	4, 451	4, 707	4, 558	4, 846	4, 846	4, 748	4, 374	4, 465	4, 295	4, 040	3, 870	3, 700	—1. 5
Beer	16, 895	18, 560	17, 778	17, 522	18, 150	19, 580	21, 792	22, 944	25, 915	30, 200	33, 870	38, 000	3. 9
Soft drinks	817	1, 082	1, 613	2, 451	3, 303	4, 116	5, 591	7, 753	11, 277	18, 100	24, 700	34, 000	11. 8
Total beverages	22, 163	24, 349	23, 949	24, 819	26, 299	28, 444	31, 757	35, 162	41, 487	52, 340	62, 440	75, 700	6. 2
Pet food	4, 152	4, 320	4, 488	4, 475	4, 654	4, 625	4, 832	5, 134	5, 486	6, 320	7, 030	7, 810	3. 6
Pressure packing	(a)	(a)	1, 399	1, 651	2, 188	2, 501	3, 049	3, 795	3, 800	4, 350	5, 520	6, 500	5. 5
Nonfood:													
Oil	5, 760	6, 190	5, 194	6, 026	6, 304	3, 995	3, 203	3, 168	3, 229	3, 940	4, 570	5, 600	5. 7
All other nonfood	12, 380	13, 377	10, 706	11, 068	11, 288	11, 194	11, 309	11, 626	11, 548	12, 930	13, 360	14, 130	2. 0
Total metal cans	103, 300	107, 187	105, 111	109, 357	114, 505	110, 042	116, 212	121, 205	129, 282	146, 100	161, 190	180, 290	3. 4

[a] 1958, 1959 included in all other nonfood.

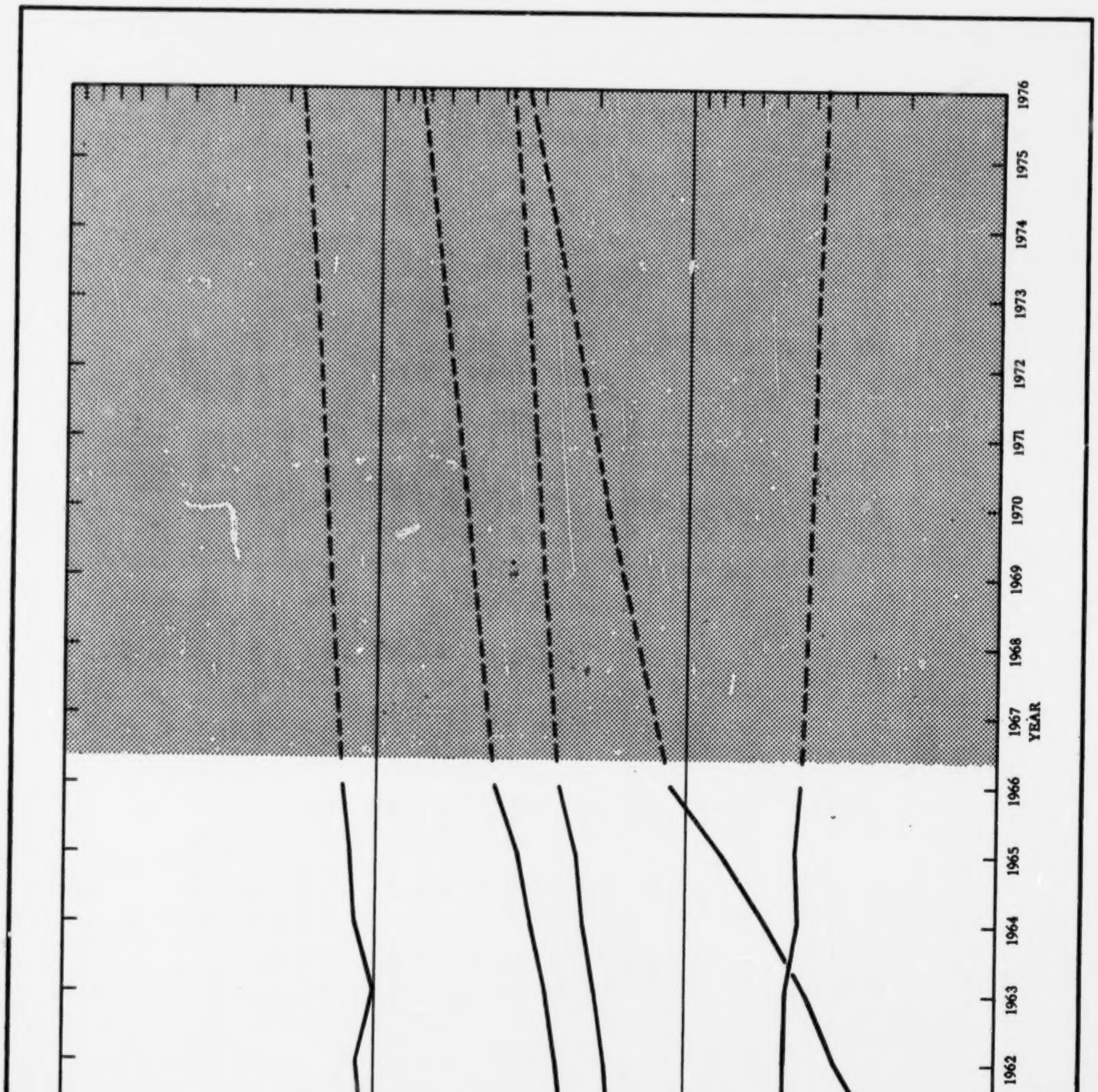
Source: U.S. Department of Commerce, Bureau of the Census. Metal cans, *Current Industrial Reports*, Series M340, (59–13)—M34 (66–13). Washington, D.C., 1960–1967. Forecasts by Midwest Research Institute.

TABLE 30.—*Number of cans consumed by end use: 1958 to 1976*

Millions of cans

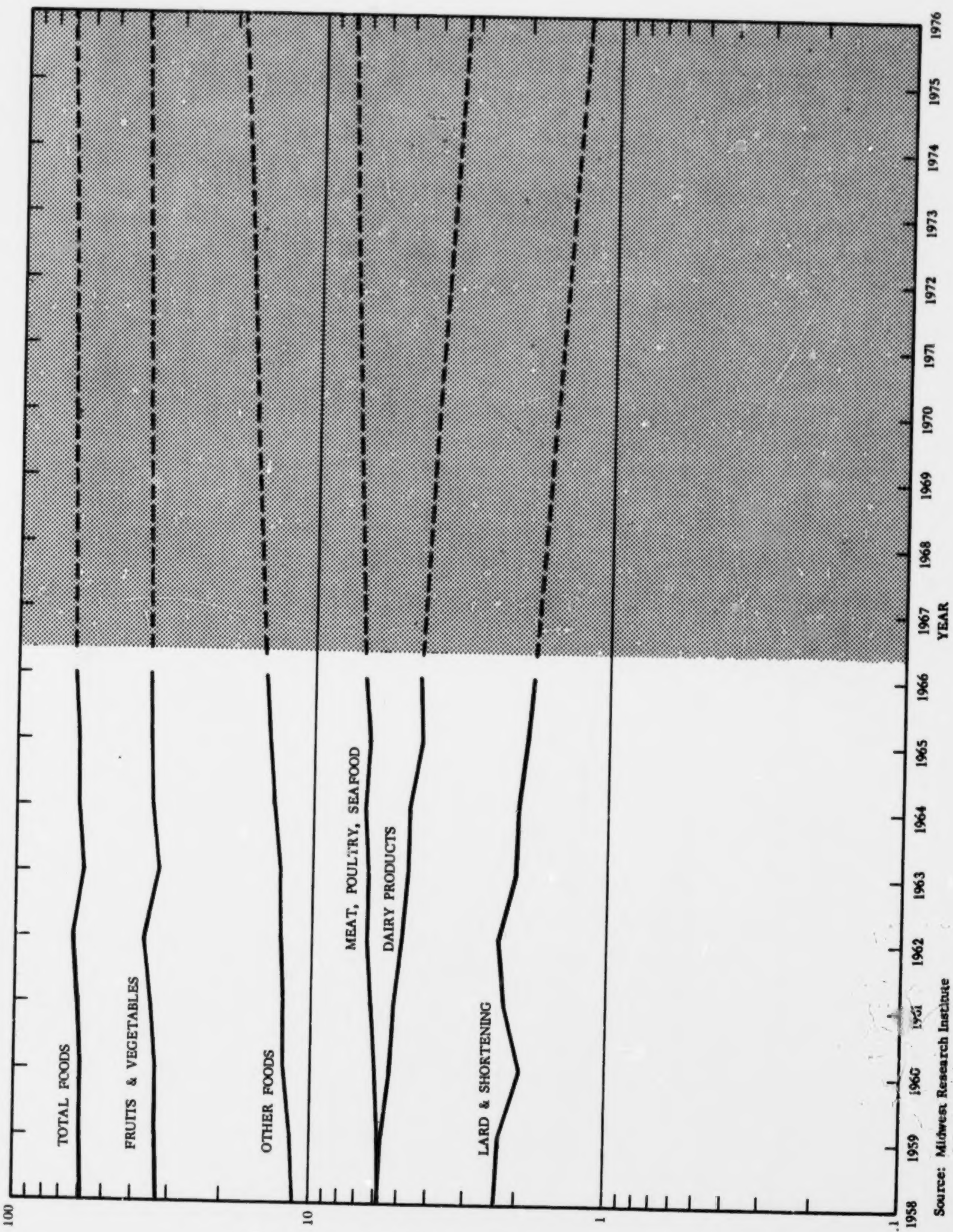
End use	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976	1966 to 1976 rate of change (percent)
Food—beverage:													
Fruit and fruit juices, veg. and veg. juices	14, 582	14, 340	14, 262	14, 248	15, 560	13, 817	14, 267	14, 345	14, 434	14, 960	15, 370	15, 790	0. 9
Evaporated milk and other dairy products	3, 002	2, 937	2, 569	2, 585	2, 439	2, 229	2, 248	2, 199	2, 257	2, 000	1, 820	1, 670	−3. 0
Meat and poultry, fish and seafood	2, 854	2, 851	2, 957	3, 089	3, 206	3, 153	3, 203	3, 143	3, 268	3, 470	3, 630	3, 790	1. 5
Lard and shortening	306	299	331	396	413	339	339	347	335	280	250	220	−4. 1
Baby food and formulae, all other foods	4, 818	4, 937	6, 394	6, 477	6, 525	6, 558	6, 939	5, 664	5, 870	6, 480	6, 980	7, 520	2. 5
Total foods	25, 562	25, 364	26, 513	26, 795	28, 143	26, 096	26, 996	25, 698	26, 164	27, 190	28, 050	28, 990	1. 0
Coffee	939	993	993	1, 053	1, 054	1, 130	1, 042	1, 044	998	940	900	860	−1. 5
Beer	8, 337	9, 156	8, 888	8, 761	9, 075	9, 324	10, 896	11, 382	12, 947	15, 100	16, 930	19, 000	3. 9
Soft drinks	409	548	812	1, 225	1, 651	2, 058	2, 795	3, 841	5, 612	9, 000	12, 300	17, 000	11. 7
Total beverages	9, 685	10, 697	10, 693	11, 039	11, 780	12, 512	14, 733	16, 267	19, 557	25, 040	30, 130	36, 860	6. 5
Pet food	1, 968	2, 051	2, 136	2, 131	2, 216	2, 202	2, 301	2, 551	2, 740	3, 160	3, 510	3, 900	3. 6
Pressure packing			743	786	1, 042	1, 000	1, 220	1, 577	1, 580	1, 810	2, 300	2, 700	5. 5
Nonfood:													
Oil	1, 575	1, 693	1, 429	1, 507	1, 576	1, 080	866	856	873	1, 070	1, 240	1, 510	5. 6
All other nonfood	4, 500	4, 869	2, 859	3, 334	3, 404	3, 013	3, 008	3, 515	3, 522	3, 940	4, 070	4, 310	2. 0
Total metal cans	43, 290	44, 674	44, 373	45, 592	48, 161	45, 903	49, 124	50, 464	54, 436	62, 210	69, 300	78, 270	3. 7

Source: Can Manufacturers Institute. *Annual Report, Metal Can Shipments—1966.* Washington, D.C., 1967. Forecasts by Midwest Research Institute.



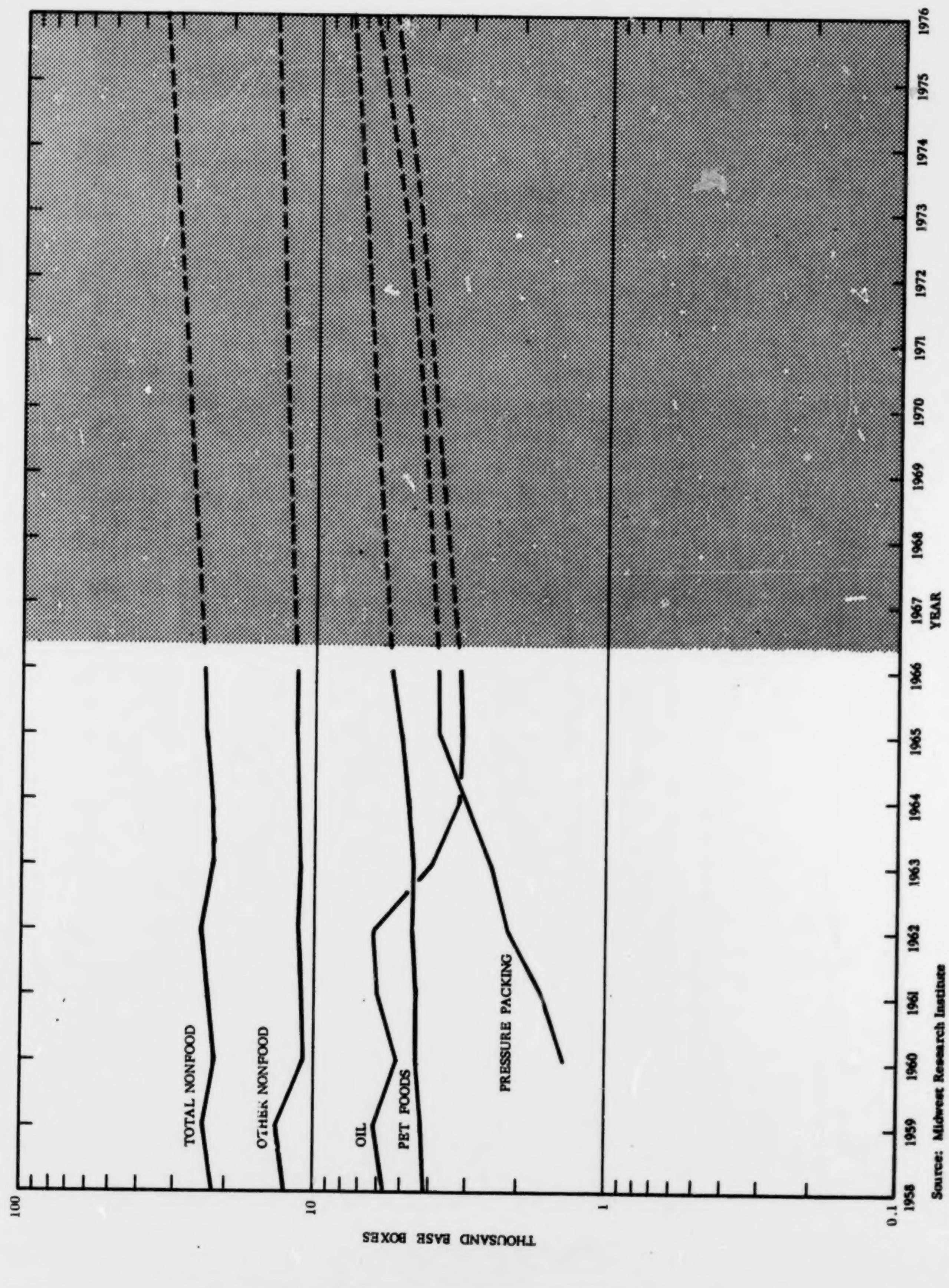
Source: Midwest Research Institute

FIGURE 17.—Shipments of metal cans by end use: 1958–1976 (thousand base boxes)



Source: Midwest Research Institute

FIGURE 18.—Shipments of metal cans by end use—Food: 1958–1976 (thousand base boxes)



Source: Midwest Research Institute

FIGURE 19.—Shipments of metal cans by end use—Nonfoods: 1958–1976 (thousand base boxes)

workable; the exterior of aluminum cans can be attractively decorated, and manufacturing techniques for aluminum containers allow versatility in size, shape, and wall thickness. There are four basic aluminum can types, differentiated by the production method used to fabricate them:

(1) *Impact extruded cans* are produced by striking a slug of aluminum with a metal punch. The metal flows around the punch to form a cup, which is then ironed by draw dies to create the sidewall.

(2) *Three-piece cans* are produced on standard can manufacturing machinery. The side seam is bonded with an adhesive rather than soldered.

(3) *Draw and ironed cans* are created by drawing an aluminum sheet into a cup, then deepening or lengthening the side by ironing.

(4) *Draw cans*, usually twice as wide as they are high, are made by drawing sheet aluminum into a shallow cup. Snack and cheese dip containers are examples of such containers.

For some applications aluminum cans have gained an advantage over steel cans, and the former are likely to increase their share of the can market at a fairly rapid pace.

Trends in Steel

Until recently, all steel cans (usually called "tin cans") were made from standard tin-plate steel. (The tin is necessary to form a solder bond; it serves no other purpose. The interior protection is provided by special resin coatings.) Recently "thin-tin," a lighter gauge of tin plate, has been developed, which yields more cans per unit of metal than standard tin-plate steels. Given its present strength and structural rigidity, thin-tin is somewhat limited, however. It cannot be used for products that are packaged under high vacuum because the containers tend to collapse; its major use is primarily in beer and carbonated beverage packaging.

Thin-tin, however, is not the most ideal material for metal cans because of its tin content. The can manufacturing industry has long been vexed by sudden variations in the price and supply of tin as a result of political instabilities in Bolivia and Malaysia—the major source locations of tin. To avoid these fluctuations, can manufacturers have sought for and discovered a way to make tin-free steel (TFS) cans. The material has been developed, and two of the most important technological problems of tin-free steel—side seaming and coating—have been solved.

One side seaming method uses a thermo-plastic cement; another employs a special heat induction welding process that produces a barely noticeable seam. This last method enables full, wrap-around, direct lithographic decoration of the can. The wrap-around decoration produces a more attractive container which is especially desirable in packaging consumer products. Special resin and enamel coatings, have been developed for tin-free steel cans to perform the protective and decorative functions.

Today, tin-free steels account for less than 10 percent of all steel cans. Eventually, however, such cans could displace tin-plate cans; by 1976, perhaps 50 percent of all steel cans will be made from tin-free steels. Tin-free steels are less expensive than tin plate. For example, in 1965 the price of tin-plate was $8.55 per base box versus tin-free steel at $7.20. The primary deterrents to the more widespread acceptance of tin-free steel at this time are the relatively high capital investment required to change over from tin-plate to TFS, and refinement of the production technology. Also, food packagers must test these new units extensively to be assured that performance of the new TFS cans will equal that of tin-plate steel.

Another significant current development both in aluminum and steel cans has been the introduction of easy-open devices for beverage containers. Many beverage cans now have this easy-open device; and this feature is beginning to appear on cans for sardines, sausages, and other specialty foods. How far these devices will spread throughout the can market is not clear—consumers want convenient packages, but many still use can openers on cans with easy-open devices, either from habit or from dissatisfaction with the devices.

Aerosol Containers

Aerosols are convenient but expensive packages. The price of any product in an aerosol container is considerably higher than that of the same product in any other container. About 95 percent of all aerosols are cylindrical tin-plate containers. The remainder is made of glass and plastic (Table 31).

Household products (air fresheners, window sprays, waxes, paints, etc.) and personal care products (hair sprays, personal deodorants, shaving lather, etc.) accounted for 78 percent of the total units filled in 1966 (Table 32). A few food products, for example, cheese snack foods and whipped cream, are packaged in aerosols, but it is unlikely that pressure packaged foods will get into high volume production in the near future, primarily because technological problems in valve design and dispensing must still be solved. Improvements must be made to prevent clogging of valves and excessive waste of the product before aerosol food containers are accepted by the consumer.

The typical aerosol container consists of a pressurized container with the product and propellant mixed inside. The product is dispensed through a valve and dispenser spout that includes an actuator device. Several new kinds of aerosols are now under development. These will eliminate the physical mixing of propellant and product and open new markets for products that are incompatible with present propellants. Some of the major types are: (1) bag-in-can—the product is inside a bag, and the propellant between the wall of the container and the bag; (2) free piston can—the propellant is contained within a piston at the bottom of the aerosol; (3) cartridge assembly unit—the unit fits inside or outside the container and applies pressure directly to the valve, in which the product and propellant travel separate passageways and are mixed only in the vapor phase as they leave the dispenser; and (4) spring action—works by pressure imbalance provided by a metal spring fitted under a plastic piston that acts as the dispensing mechanism.

Most of these new aerosols represent an improvement over the traditional type, but they are more expensive; for this reason, they have not been accepted for high unit volume products.

Another development in aerosols is the "total service" unit. Such a unit has an attachment near the dispenser that adds convenience in using the product as it is dispensed. Examples of total service units are upholstery cleaners with an attached brush and windshield de-icers with an attached scraper.

Manufacturers are also developing new propellants that are either less expensive or compatible with products that were incompatible with the old propellants.

In the last eight years aerosols have grown at the rate of 20 percent a year. Aerosol manufacturers are optimistic about the future of this container configuration; many sources in the industry predict a volume of more than 4 billion units in 1976, a prediction which we consider to be too high under prevailing market conditions.

In the future, glass, composite cans, and plastic bottles will probably account for a larger share of aerosol containers, although most such containers

Table 31.—*Nonfood aerosol containers consumed by size: 1955 to 1966*

In thousands of units

Year	Glass and plastic containers (all sizes)	Metal containers		Reported total	Complete total [a]
		Over 6 oz	6 oz and less		
1955	10,412	119,720	104,985	235,117	240,000
1956	15,093	151,035	127,062	293,190	320,000
1957	21,279	167,871	150,341	339,491	390,000
1958	11,262	171,121	159,001	341,384	470,000
1959	25,260	286,098	186,930	498,288	575,000
1960	42,902	364,810	199,280	606,992	670,000
1961	34,942	445,238	196,082	676,262	796,000
1962	44,237	541,917	196,042	782,196	1,019,000
1963	37,658	702,644	175,684	915,986	1,135,000
1964	57,373	789,512	206,681	1,053,566	1,293,000
1965	77,762	977,611	304,743	1,360,116	1,711,200
1966	73,015	1,083,310	287,578	1,443,903	1,800,000

[a] Adjusted to include estimated nonreported total.

Note: The unit total for metal does not correspond with that under metal cans because the reporting and data gathering approaches differ somewhat between the Can Manufacturers Institute and CSMA.

Source: Chemical Specialties Manufacturers Association, Inc. *Aerosol and Pressurized Products Survey*. Annual reports for 1958–66. New York.

will continue to be metal. Improvements in technology will probably lead to dispensers being used more for food and drug products. There will be a greater volume of aerosols in 1976, although it is likely that they will be in radically different forms.

Despite the increase in volume, metal aerosols will still account for only a small percent of total packaging containers in 1976. We expect the unit output of metal aerosol containers to grow at the rate of 5.5 percent a year, from 1.6 billion units in 1966 to 2.7 billion units in 1976.

Competing Materials

Metal cans are in competition with composite cans, glass, and plastic containers. Cans have been extremely successful in their competition with glass bottles for the beverage container market; and this success is likely to continue. As shown in Table 28, beverage cans will have a growth rate more than six times greater than food cans in the next 10 years. Of course, steel and aluminum are in competition with each other for the same can markets; and the different kinds of steel cans also compete with one another.

Aluminum's share of the beer can market is likely to increase substantially in the near future as more major breweries switch to aluminum cans; soft drink manufacturers may follow suit. The only other area where aluminum is likely to enter the market in the next few years on a volume basis is seafood canning.

The amount of metal used for cans might be further reduced by the use of clear plastic tops on cans. Such a top has been developed, and although there are still many problems, it may soon be tried on cans of sliced fruit. If the clear plastic top is adopted on a wide-scale basis, which we do not foresee, the amount of metal used in cans would be reduced.

Metal Cans: Summary Outlook

The use of lighter steels, more aluminum, and technological advances in both steel and aluminum cans will lead to a rate of growth in the number of units consumed that is twice as high as the rate of growth of pounds of metal consumed in producing cans.

We expect the number of cans to grow at a rate of 3.7 percent a year, resulting in an increase from 54.4 billion units in 1966 to 78.3 billion units in 1976. The consumption of steel and aluminum in cans will grow at the rate of 1.8 percent per year, from 10.68 billion pounds in 1966 (10.35 billion steel and 0.33 billion aluminum) to 12.82 billion pounds in 1976 (11.42 billion steel and 1.40 billion aluminum).

Aluminum Foil

In addition to cans, aluminum foil is also used for semi-rigid containers and other foil forms such as in laminates. In fact, 8.1 percent of all aluminum shipments in 1966, or 683 million pounds, went into packaging applications. Although aluminum has a relatively small share of the metal packaging market, this share will undoubtedly increase because of the many advantages aluminum has over other materials and because of advancements in technology. Total aluminum consumption in packaging (including aluminum cans) to 1976 is shown in Table 33.

Aluminum is highly competitive with other materials. The properties of aluminum enable it to be tailored to meet the performance and application requirements of many products. Aluminum packaging materials provide excellent moisture, vapor, and gas barriers. In thicknesses above 0.001 inch, the material is almost totally impermeable. Aluminum can be attractively decorated, it has good heat conductivity, and performs well in heating, freezing, and drying processes.

Aluminum metallurgy has not completely matured and it is likely that significant new packaging applications will be developed in the future.

Semi-Rigid Aluminum Foil Containers

The semi-rigid foil container is most frequently used for products in which the barrier properties and heat conductivity of aluminum combine to make a convenient consumer package. Semi-rigid containers have been particularly successful in prepared and pre-cooked foods such as bakery products (pies and cakes) and frozen meals. Semi-rigid aluminum trays and tubes are also being used for refrigerated products, such as soft margarine, and for dry products, such as hermetically sealed dehydrated vegetables. More recently, semi-rigid aluminum containers have been used for institutional foods. Prepared foods are packaged in heat-and-serve, disposable, single-service containers. These containers reduce

TABLE 32.—*Consumption of aerosol containers by end use: 1958 to 1966* [a]

In thousands of units

End use	1958	1959	1960	1961	1962	1963	1964	1965	1966
Insect sprays:									
Space insecticides	22, 318	38, 751	37, 118	36, 526	28, 616	19, 125	24, 714	23, 087	21, 730
Residual insecticides	19, 982	27, 160	20, 350	27, 067	20, 781	24, 471	17, 111	10, 823	22, 555
Total	42, 300	65, 911	67, 468	63, 593	49, 397	43, 596	41, 825	83, 910	91, 283
Coatings and finishes:									
Finishes	30, 123	52, 556	67, 207	76, 785	88, 805	112, 755	120, 738	124, 738	128, 261
Coatings						11, 416	19, 088	11, 193	10, 833
Total	30, 123	52, 556	67, 207	76, 785	88, 805	124, 171	139, 826	152, 927	161, 094
Household products:									
Room deodorants and disinfectants	49, 780	59, 724	66, 755	64, 591	61, 094	77, 659	54, 921	88, 052	85, 195
Cleaners	3, 667	18, 470	17, 678	25, 585	23, 189	40, 125	70, 281	61, 146	78, 895
Waxes and polishes		11, 843	40, 204	17, 032	17, 604	14, 961	17, 740	24, 491	24, 652
Starches and laundry products			19, 796	46, 351	54, 408	78, 182	103, 938	128, 687	147, 652
All other household products	22, 210	47, 296	32, 380	25, 645	26, 519	20, 760	27, 509	9, 386	11, 711
Total	75, 657	137, 333	176, 813	179, 204	182, 814	231, 687	274, 389	486, 762	531, 105
Personal products:									
Shaving lather	45, 314	72, 611	68, 174	82, 353	79, 995	84, 567	104, 352	92, 908	106, 156
Hair spray	92, 594	79, 687	111, 861	140, 216	225, 217	253, 052	270, 205	423, 687	391, 451
Medicinals	7, 130	10, 036	11, 777	18, 038	31, 301	37, 782	28, 618	35, 027	37, 424
Colognes and perfumes	13, 563	34, 077	39, 021	47, 465	44, 222	30, 926	47, 644	63, 917	66, 300
Personal deodorants	20, 241	23, 483	12, 866	16, 526	37, 985	33, 189	76, 108	157, 265	171, 973
Other personal products								32, 856	18, 438
Total	178, 842	219, 894	243, 699	304, 598	418, 720	439, 517	526, 927	905, 660	890, 742
Animal products: Veterinarian and pet products	3, 002	4, 113	4, 711	7, 145	6, 348	7, 560	6, 514	8, 785	8, 423
Total	3, 002	4, 113	4, 711	7, 145	6, 348	7, 560	6, 514	8, 785	8, 423

Automotive: All types of products				(b)	(b)	30, 277	28, 723	26, 786	20, 337
Total						30, 277	28, 723	29, 786	23, 337
Industrial products: Oils, greases, etc							10, 094	14, 052	18, 691
Total							10, 094	16, 052	20, 691
Food products: All types							21, 543	49, 773	34, 558
Total							21, 543	89, 773	69, 558
Miscellaneous	11, 460	18, 013	28, 927	33, 472	35, 787	35, 643	4, 827	21, 568	18, 588
Total for all categories too revealing to be released		466	18, 166	11, 465	327	3, 535	20, 445	1, 666	20, 006
Total	11, 460	18, 479	47, 093	44, 937	36, 114	39, 178	25, 272	27, 234	38, 594
Reported total	341, 384	498, 286	606, 991	676, 262	782, 198	915, 986	1, 075, 113	1, 409, 893	1, 443, 829
Grand total, adjusted	513, 000	625, 000	730, 000	856, 000	1, 083, 000	1, 202, 000	1, 365, 000	1, 800, 889	1, 834, 829

[a] Categories may not total due to figures having been adjusted to include nonreported data.
[b] Included in miscellaneous.

Source: Chemical Specialties Manufacturers Association, Inc. *Aerosol and Pressurized Products Survey*. Annual reports for 1958–1966. New York.

TABLE 33.—*Aluminum consumed in packaging*

In millions of pounds

Year	Aluminum foil			Aluminum cans and ends	Total aluminum
	Semi-rigid foil containers	Nonrigid aluminum foil	Total foil		
1958	36	157	193	[a]	193
1959	48	185	233	[a]	233
1960	54	174	228	50	279
1961	57	190	247	65	312
1962	66	202	268	76	343
1963	72	218	290	170	460
1964	80	238	318	220	538
1965	85	251	336	275	611
1966	88	266	354	329	683
1970	110	350	460	700	1,160
1973	130	400	530	1,000	1,530
1976	150	465	515	1,400	2,015

[a] Not available.

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging*, 20(1): 9, April 1967. *Modern Packaging Encyclopedia*, William C. Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p. The Aluminum Association. *Aluminum Statistical Review—1966*. New York, July 1967. Forecasts by Midwest Research Institute.

labor requirements, equipment needs, and sanitation problems in hospitals, schools, and other institutions.

Recent technological developments have been in the areas of alloys, new forming techniques, and combinations with plastics. New alloys that allow deeper drawing and more flexibility in configuration have been developed. Other alloys have produced lighter, stronger containers. New package-forming processes include air forming or air blowing of the foil against a mold to form the package. The air blowing technique produces a smooth, attractive container that may be used for frozen meals.

Aluminum packagers are effectively combining semi-rigid aluminum containers with plastics, either as coatings or transparent coverings that both protect the product and make it visible.

Semi-rigid foil containers will grow substantially in volume in the next few years because of the increasing number of convenience food products that will use aluminum containers. Growth should take place at a rate of 5.5 percent a year, with consumption rising from 88 million pounds in 1966 to 150 million pounds in 1976.

Nonrigid Aluminum Foil

Nonrigid, flexible aluminum foils range in thickness from 0.00025 to 0.00059 inch. These foils are not self-supporting and are usually combined with other materials, such as paper or plastic. In 1966, 266 million pounds of foil were used for packaging purposes. Of this total, 126 million pounds were household wrap and 140 million pounds were used in commercial packages. The latter figure, measured in square inches, amounted to about 4.1 billion MSI (1,000 square inches). By comparison, 7.7 billion MSI cellophane and 21.1 billion MSI polyethylene film were produced in the same year.

Nonrigid aluminum foil is applied either on the outside of a package to enhance its appearance or on the inside to act as a barrier material. This material is almost always combined with paper or film so that it can be handled easily in converting and packaging operations.

End uses of this material are shown in Table 34 as quantities and in Table 35 as a percentage of shipments.

New foils have been developed with more strength and ductility so that they can be formed in the new shapes without overstressing. Foil is also being combined with other materials to produce an aluminum foil laminate that will stand up on vertical form-fill-seal machinery and thus will be more adaptable to rapid handling in pouch form.

The aluminum foil laminate may be particularly successful with convenience food products, "unit of use" packaging such as single portion catsup, multiple pouches, and snack food items. Laminated foil liners are now used extensively as the barrier material in boxes of sugar-coated breakfast cereals.

As a laminate, aluminum foil has some competition from plastic coatings and other materials. However, in containing liquids and foods, aluminum foil laminates have many natural advantages not shared by the other materials, such as impermeability and high strength, so the competition is not too great at this time.

One product, steel foil, was designed specifically to compete with aluminum foil, but has not been successful. There has been considerable interest in the packaging industry in steel foil because of its many advantages—it has high tensile and compression strength; it can be formed by bending, creasing, soldering, corrugating, laminating, and other processes; it is puncture resistant; and it is impervious to vapor and moisture. In spite of these merits, steel foil has not been accepted because its advantages are outweighed by its disadvantages—it is difficult to cut and handle; there are no satisfactory adhesives to use in lamination; packages of steel foil are difficult to open; and the price of steel foil is relatively high. Because of the many problems of steel foil, it is unlikely that it will have an impact on aluminum foil in the near future.

With continuing advances in food technology, development of new foods, convenience packaging, and improvements in foils, aluminum foil should be a rapidly growing packaging material. We forecast a growth rate of 5.7 percent a year and growth in foil use from 266 million pounds in 1966 to 465 million pounds in 1976. This growth

TABLE 34.—*Consumption of aluminum foil by end use: 1958 to 1965, in millions of pounds*

End-use product group	1958	1959	1960	1961	1962	1963	1964	1965
Semi-rigid foil containers:								
Frozen, precooked foods, dairy products, etc	34.3	45.2	51.2	54.9	64.4	70.1	76.8	79.7
Other foods	1.6	2.7	2.4	2.2	2.1	2.0	2.9	5.2
Total semi-rigid foil containers	35.9	47.9	53.6	57.1	66.5	72.1	79.7	84.9
Nonrigid foil:								
Food:								
Dairy products and edible oil products	9.6	9.9	10.2	9.3	9.1	9.8	10.1	10.8
Dried and dehydrated food products	1.5	2.0	1.9	2.5	1.9	1.6	2.0	2.7
Cookies, crackers, baking products, bread, cereals, and kindred products	6.0	7.3	6.3	6.9	7.1	8.5	7.1	8.3
Meat, poultry, and seafoods	.6	.8	.6	.7	.7	1.1	1.5	1.7
Chocolate, coffee, tea, gelatins, deserts mixes, powders, salt, sugar, etc	2.3	2.2	2.2	2.3	2.9	3.0	3.0	2.8
Gum, confections, snacks, nuts, etc	9.0	9.3	9.0	9.3	9.1	9.8	10.7	12.5
Total food nonrigid	29.0	31.5	30.2	31.0	30.8	33.8	34.4	38.8
Nonfood:								
Tobacco	16.6	21.1	18.5	21.8	19.9	20.7	19.6	21.2
Industrial parts, rubber goods, tape, soaps, chemicals, photographic and x-ray film, photographic paper, corrugated shippers, etc.	7.0	7.8	6.7	6.5	8.6	13.3	16.2	16.9
Total nonfood	23.6	28.9	25.2	28.3	28.5	34.0	35.8	38.1
Other:								
Cap liners and packaging closures	8.7	9.4	8.9	8.3	8.0	8.2	7.5	6.6
Labels, tags, seals, and beverage wraparounds	9.4	9.3	9.0	8.8	9.2	9.2	9.2	9.6
Military packaging (direct and indirect orders)	1.2	1.4	1.0	1.1	1.2	2.1	3.7	5.4
Decorative papers, gift wrap, etc	7.3	9.4	11.4	10.4	9.5	12.0	12.9	11.6
Locker plant, freezer, restaurant, and household packaging	59.1	75.4	72.5	82.7	94.8	101.4	113.7	116.1
Unknown end use, scrap and waste	18.4	19.5	16.3	19.2	19.0	17.5	21.4	24.4
Total other	104.1	124.4	119.1	130.5	141.7	150.4	168.4	173.7
Total nonrigid foil	156.7	184.8	174.5	189.8	201.0	218.2	236.8	250.6
Grand total—aluminum foil	192.6	232.7	228.1	246.9	267.5	290.3	318.3	335.5

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging*, 20(1):9, April, 1967. Modified by Midwest Research Institute.

rate is based on a faster growth rate (about 6.8 percent a year) until 1970 and a slower growth rate (about 5.0 percent) thereafter. The slow down in the growth rate is expected to occur because traditional aluminum markets will mature and alternate barrier materials will be developed and will displace some aluminum foil.

Collapsible Metal Tubes

Collapsible metal tubes are used primarily to package and dispense semi-liquid or pasty products such as toothpaste, cosmetics, and glue (Tables 36 and 37). These tubes are convenient, easy to store, and dispense the product in an easy, sanitary fashion.

The metals most often used are tin, tin-lead, lead, and aluminum (Table 38). The type of metal used and the internal protective coating required are determined by the characteristics of the product. More tubes are made from aluminum than any other metal; however, a greater quantity of lead is consumed because lead weighs much more per unit. Tin is most often used for products that require a chemically inert container, as for eye ointments. The usual coatings for tubes include wax and resins such as vinyls, phenolics, and epoxies.

TABLE 35—*Consumption of aluminum foil by end use: 1958 to 1965, in percent of total pounds*

End-use product group	1958	1959	1960	1961	1962	1963	1964	1965
Semi-rigid containers:								
Frozen, precooked, dairy, etc	17.8	19.4	22.4	22.2	24.1	24.1	24.1	23.8
Other foods	.8	1.2	1.1	.9	.8	.7	.9	1.5
Total semi-rigid foil	18.6	20.6	23.5	23.1	24.9	24.8	25.0	25.3
Nonrigid foil:								
Food:								
Dairy products and edible oils	5.0	4.3	4.5	3.8	3.4	3.4	3.2	3.2
Dried and dehydrated food products	.8	.9	.8	1.0	.7	.5	.6	.8
Cookies, baking, cereal, and kindred products	3.1	3.1	2.8	2.8	2.6	2.9	2.2	2.5
Meat, poultry, and seafoods	.3	.3	.3	.3	.3	.4	.5	.5
Chocolate, coffee, tea, gelatins, powders, etc	1.2	.9	1.0	.9	1.1	1.0	.9	.9
Gum, confections, snacks, nuts, etc	4.7	4.0	3.9	3.8	3.4	3.4	3.7	3.7
Total food	15.1	13.5	13.3	12.6	11.5	11.7	10.8	11.6
Nonfood:								
Tobacco	8.6	9.1	8.1	8.8	7.4	7.1	6.2	6.3
Industrial parts, chemicals, photographic, etc	3.6	3.3	2.9	2.6	3.2	4.6	5.1	5.0
Total nonfood	12.2	12.4	11.0	11.4	10.6	11.7	11.3	11.3
Other:								
Cap liners and packaging closures	4.5	4.1	3.9	3.4	3.0	2.8	2.4	2.0
Labels, tags, seals, beverage wraparounds	4.9	4.0	3.9	3.6	3.4	3.2	2.9	2.9
Military (direct and indirect)	.6	.6	.4	.4	.5	.7	1.2	1.6
Decorative papers, gift wrap, etc	3.8	4.0	5.0	4.2	3.6	4.1	4.0	3.4
Locker plant, freezer, restaurant, household	30.7	32.4	31.8	33.5	35.4	35.0	35.7	34.6
Unknown end use, scrap, and waste	9.6	8.4	7.2	7.8	7.1	6.0	6.7	7.3
Total other	54.1	53.5	52.2	52.9	53.0	51.8	52.9	51.8
Total nonrigid foil	81.4	79.4	76.5	76.9	75.1	75.2	75.0	74.7
Total—aluminum foil	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Table 34.

The most significant current development in tube making is the appearance of laminated, composite tubes. One such container, made of layers of polyethylene, foil, paper, and a second polyethylene layer has already been introduced commercially. A composite tube has several advantages over an all-metal-tube—lower cost, compatibility with products which cannot be packaged at present in all-metal tubes, and better printability.

There is some interest in using tubes for food products; however, consumers do not seem too eager to switch to this form of food packaging.

Cosmetics and pharmaceuticals seem to have the most promise in new applications for tubes.

Aerosols and plastic tubes have taken some of the markets previously held by metal. Plastic tubes are being used increasingly for cosmetics, where the nonbreakability, transparency, and durability of plastics make them especially

Table 36.—*Shipments of collapsible tubes by end use: 1958 to 1966, in millions of units*

End use	1958	1959	1960	1961	1962	1963	1964	1965	1966
Dentrifices	513	581	579	609	529	582	637	619	623
Medicinal, pharma	204	249	234	248	258	283	302	287	338
Household, industrial	166	176	169	159	163	152	160	194	208
Cosmetics	78	104	113	123	112	159	125	173	147
Shaving cream	43	39	32	25	20	20	19	14	19
Food products	.6	.6	.6	.6	.7	.7	.6	1	5
Total	1,004.6	1,149.6	1,127.6	1,164.6	1,082.7	1,196.7	1,243.6	1,288	1,340

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging*, 17(2): 23, June 1964. *Ibid.* 18(3): 20, October 1965. *Modern Packaging*, 40(9): 103, May 1967. Midwest Research Institute.

Table 37.—*Shipment of collapsible tubes by end use: 1958 to 1966, in percent of shipment*

End use	1958	1959	1960	1961	1962	1963	1964	1965	1966
Dentifrices	51.0	50.5	51.3	52.3	48.8	48.7	51.2	48.0	46.5
Medicinal, pharmaceutical	20.3	21.6	20.8	21.3	23.8	23.7	24.3	22.3	25.2
Household, industrial	16.5	15.3	15.0	13.6	15.0	12.7	12.9	14.7	15.5
Cosmetics	7.8	9.1	10.0	10.5	10.4	13.2	10.0	13.6	11.0
Shaving cream	4.3	3.4	2.8	2.2	1.9	1.6	1.5	1.3	1.4
Food products	.1	.1	.1	.1	.1	.1	.1	.1	.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Table 36.

Table 38.—*Shipments of collapsible tubes by type of metal: 1958 to 1966*

In thousands of pounds

Type of metal	1958	1959	1960	1961	1962	1963	1964	1965	1966
Tin	1,194	1,422	1,153	1,344	1,187	1,285	1,353	....	....
Tin-coated lead	689	731	639	493	427	389	390	....	....
Lead	13,777	13,082	15,827	22,569	22,959	28,305	26,217	....	....
Tin-lead alloy	560	645	694	449	506	535	416	....	....
Aluminum	8,196	9,891	9,401	8,417	7,839	9,397	10,146	....	....
Total	24,416	25,772	27,714	33,272	32,918	39,911	38,522	35,000	32,000

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging*, 17(2): 24, June 1964. *Ibid.* 18(3): 20, October 1965. Midwest Research Institute.

attractive containers. Water-based and oil-water emulsions (shampoos, creams, lotions) perform well in plastics, but products that are oxygen sensitive or permeable through plastics are difficult to package in plastic tubes.

The development of plastic tubes has been a major factor inhibiting the growth rate of metal tubes. In recent years the number of metal tubes has varied between 1.1 and 1.3 billion units, or about 30 to 35 million pounds of metal. Plastic tubes now account for 250 million units.

Competing materials and packaging forms, and the problems presented by product compatibility with the metal tube, are deterrents to their more extensive use. Because of these factors, volume should decline in metal tubes—from 32 million pounds of metal in 1966 to 25 million pounds in 1976. The rate of decline will be about 2.4 percent a year.

Steel Drums and Pails

Steel drums and pails are used primarily for shipping liquid or paste-type products—chemicals, petroleum, adhesives, paints, and the like. Steel drums and pails were once used in volume to ship dry products, but now other types of containers, such as fiber drums and multiwall bags, are used. Tables 39 and 40 give shipments of these containers by end use in number of units and as percent of market held for the years 1958 through 1966.

Steel drums and pails have had a modest growth rate in recent years. In 1958, 31.5 million new drums were shipped; by 1966, shipments had advanced to 35.8 million units. Corresponding figures for steel pails are 72.2 million units in 1958 and 89.1 million units in 1966. Since 1959, the amount of steel used for drums and pails has remained steady at around 1.6 billion pounds.

Recent trends in steel drums and pails are toward improved materials, better decoration, improved shapes, use of coatings and linings, and less reconditioning and re-use.

Lighter gauge steels and improved structural designs have been developed to increase unit strength, improve its performance, or reduce its weight.

Steel drums and pails are being given a better appearance by use of more decoration to promote brand names and the quality of the product inside the container.

Pails that nest together to save space in storage and shipping, drums that can be taken apart, and sidewalls that nest together for shipping prior to filling have been designed.

Improved coatings and linings to protect both the product and the container have been developed. The most important coatings are phenolics, epoxies, and vinyls. Polyethylene liners of 10 to 15 mil thickness are being used with either steel or fiber outer shells.

At present, drums are reconditioned and reused at the rate of about 50 million units per year. However, reconditioning of drums has become less important as the lighter gauge drums replace the heavier drums, which have a 20-gauge body and an 18-gauge head. The lighter gauge steel drums can be reconditioned only a few times, if at all. The most important factor—cost to the user—seems to favor the use of the lighter gauge drums. For example, an 18-gauge drum that is reconditioned 15 times may have an average cost per trip of around $2.50 (original cost plus 15 reconditionings). A lighter gauge steel drum may cost about $3.00 per trip (original cost plus two reconditionings). However, the user saves a substantial amount on freight cost because an 18-gauge, 55-gallon drum weighs about 48 pounds and a 24-gauge drum of the same capacity weighs only 30 pounds. Also, reusable drums consume a good deal more record keeping time. Because of these cost factors the lighter gauge drum seems to be the least expensive to the user; it is more than likely that the heavier gauge steel drums will be displaced by lighter gauge drums and drums made from other materials.

Steel drums and pails are feeling some competition from other materials that perform satisfactorily for one trip service—fiber drums, corrugated containers, multiwall bags, and plastics. It is unlikely, however, that fiber or plastic drums will replace steel drums for most liquid or paste products in the near future. Blow-molded plastics for liquid chemicals have made

TABLE 39.—*Shipments of steel shipping barrels, drums, and pails: 1958–1966*

In thousands of units

Container type	1958	1959	1960	1961	1962	1963	1964	1965	1966
Shipping barrels and drums:									
Heavy type, total	19,018	20,467	17,949	18,874	20,192	20,057	21,381	21,209	(b)
55-gal, 16- and 18-gauge	15,359	15,797	12,932	12,715	13,000	12,930	13,967	13,182	(b)
55-gal, 19-gauge and lighter	(a)	(a)	(a)	(a)	245	258	232	338	(b)
55-gal, 20/18-gauge	586	1,541	2,217	3,082	3,900	3,713	4,180	4,609	(b)
All other heavy type bbls	3,073	3,129	2,800	3,077	3,047	3,156	3,002	3,080	(b)
Light type	9,315	10,170	9,531	9,537	9,602	9,234	9,514	9,794	(b)
Grease drums	3,158	2,891	3,106	3,134	3,172	3,007	2,931	2,924	(b)
Total	31,491	33,528	30,586	31,545	32,966	32,298	33,826	33,927	35,765
Steel shipping pails:									
Tapered pails	9,039	9,894	8,419	9,636	12,368	16,207	19,198	22,055	26,981
Dome top pails	4,143	4,027	4,189	4,489	4,488	4,606	4,526	5,262	4,431
Other types, total	58,997	66,729	61,138	62,138	62,442	58,260	59,052	60,173	57,237
Total	72,179	80,650	73,842	76,263	79,298	79,073	82,776	87,495	88,649

[a] Included in figures for 55-gal, 20/18-gauge, and lighter.
[b] Not available.

Source: U.S. Department of Commerce, Bureau of the Census. Steel shipping barrels, drums, and pails. *Current Industrial Reports*, Series M34K(59–13)—M34K(66–12). Washington, D.C., 1960–1967.

TABLE 40.—*Shipments of steel barrels, drums, and pails by end use: 1958–1966*

In percent of unit shipments

Container type	1958	1959	1960	1961	1962	1963	1964	1965	1966
Steel barrels, drums:									
Chemicals	41.7	47.8	50.4	52.4	51.4	51.7	51.1	51.8	54.3
Petroleum	38.6	28.9	27.5	27.0	26.5	25.4	24.0	25.1	26.8
Paint and printing ink	4.5	5.8	5.1	5.0	6.2	6.4	5.8	6.7	6.1
Industrial maintenance	1.7	2.2	2.3	2.4	2.3	2.6	3.5	3.8	2.9
Food	4.7	4.8	3.4	3.6	4.9	6.3	5.8	4.4	3.6
All other (adhesives, roofing, etc.)	8.8	10.5	11.3	9.6	8.7	7.6	9.8	8.2	6.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Steel pails:									
Chemicals	19.1	18.9	19.8	18.0	18.6	19.2	18.6	28.2	19.7
Petroleum	21.1	17.6	18.1	16.4	15.9	16.2	16.0	19.7	20.1
Paint and printing ink	28.3	33.4	32.3	32.9	32.1	31.9	32.3	23.2	27.3
Industrial maintenance	4.8	5.3	5.2	4.5	4.7	5.0	5.5	5.4	5.7
Adhesives, roofing	11.9	10.4	9.8	14.8	15.4	15.5	15.2	10.5	14.0
All other (food, Armed Forces)	14.8	14.4	14.8	13.4	13.3	12.2	12.4	13.0	13.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Steel Shipping Container Institute, Inc.

some inroads in small drums and pails. Because of their high cost, most users do not use larger plastic containers.

Bulk shipment of many products, made possible by growing volume requirements, has taken away some of the market for steel drums. Many products can now be shipped in bulk in tank cars or in special bulk containers on wheels.

As a result of lighter weight per unit and continuing market erosion by competing materials, there will be a slight decline (1.5 percent annually) in the quantity of steel used in steel drums and pails. Steel consumption should dip from 1.6 billion pounds in 1966 to 1.56 billion pounds in 1976. However, the number of units should increase during this period because of the normal increase in demand for products shipped in steel drums and pails and because of the increasing use of lighter one-way containers.

Metal Strapping

Metal strapping is used primarily to unitize shipping containers such as corrugated boxes or to hold palletized loads in place. Steel is the most common strapping material because the strapping is usually applied under considerable tension, and steel can absorb heavy impact without breaking. Both heavy duty steel strapping and common cold-rolled steel strapping are used, the latter in cases in which there is not likely to be a great deal of shock or impact on the straps.

The use of steel strapping is increasing because use of unitized loads and palletizing is growing. These techniques require strong, tough steel strappings. Also, unitizing systems are set up as part of production lines, and strapping machinery can prepare the unit automatically or semi-automatically in high volume. This trend toward integration of the strapping process with the rest of the packaging operation will continue as unitizing and palletizing become more important in the distribution process.

Nonmetallic strappings, most often of nylon, polypropylene, or rayon cord, are being used on packed goods and unitized groups of packages. The nometallic strappings are more easily removed than steel strappings and are finding ready acceptance in retail stores and consumer packaging.

Nonmetallic strappings are more resilient but less dimensionally stable than steel; consequently, they are less satisfactory where continuous high tension is required. It is likely that nonmetallic strapping will displace steel strappings where the primary function of the strap is to keep a package or group of packages together rather than to absorb heavy impacts.

The trend in packaging toward unitized loads and more palletizing should more than offset the use of nonmetallic strapping in some applications. Steel strappings will grow at a rate of about 2.2 percent annually, with volume rising from 800 million pounds in 1966 to 994 million pounds in 1976.

Gas Cylinders

The production of gas cylinders varies from year to year depending on the demand for industrial gases and the retirement of old containers. These packages have a relatively long life and are used predominantly in industrial applications. However, some small cylinders are also produced for the consumer markets; these containers carry small amounts of carbon dioxide for use with gas-powered rifles and pistols and carbonation devices used in the residential bar. Of all packaging configurations considered in this report, only gas cylinders appear to be immune from competition by plastics or other materials.

Relatively steady demand should characterize gas cylinders in the 10-year period under study. Gas cylinders weighing 120 million pounds were produced in 1966; although the weight of all containers produced will vary slightly from year to year, we do not foresee any major increase or decline in this category.

Metal Caps and Crowns

More than 75 billion closures of various kinds were produced in 1966, up from about 62 billion units in 1958. The bulk of these closures in 1966, 65 billion units, were metal, the balance plastics (Table 41). Two major types of metal closures can be identified—caps and crowns.

Metal Caps

Metal caps, usually made of steel or aluminum, are used as closures for bottles, cans, jars, and tubes. Sizes, styles, and configurations exist in great variety. A list of the principal types of metal caps along with a typical application illustrates their diverse nature: screw type—catsup bottle; lug type—pickles; rolled-on—beer; snap-, fit-, and press-on types—jelly; vacuum—jelly; and tamper proof—medicines. Most metal caps are lined with some other material, such as paper, film, foil, wax, plastic, or cork, to assure a tight seal.

Improved caps offering easy opening and resealable features have recently been developed and have enjoyed widespread consumer acceptance. Plastics are the chief competitors of metal closures. Plastics are somewhat more versatile and functional than metal for some applications. They can be hinged, formed as dispenser openings, are visually more attractive, and need no liner. However, metal caps are the preferred closures for large containers of all kinds and for glass containers. Continued technological improvements and the low cost of these materials will keep metals in a strong competitive position for many years.

In 1966, 18.5 billion metal caps consumed 263 million pounds of metal. By 1976, 320 million pounds of metal will be used for metal caps—a growth rate of 2.0 percent.

Metal Crowns

Closures in the form of metal crowns are used almost exclusively for beer and soft drink containers made of glass.

It is unlikely that the basic shape of metal crowns—the fluted or rounded skirt shape—will change significantly. However, in recent years there have been a few changes in and additions to this basic closure. The familiar cork liner, for instance, has been replaced with a plastic ring.

The most significant development has been the addition of pull ring or tab extensions to the caps so that they can be opened without an opener. This easy-open closure puts glass containers on a more competitive basis with soft drink and beer cans with pull tabs. Other types of self-opening crowns, such as twist-off caps have also been developed.

The metal crown should continue to be used in quantity on beer and soft drink bottles. However, because of the gains that will be made by metal cans in beer and soft drink packaging, metal crowns will have an overall decline. This decline should be at the rate of about 0.8 percent a year, resulting in a decline of metal consumption from 400 million pounds in 1966 to 380 million pounds in 1976.

PLASTICS

Probably no other material merits as much attention in packaging circles as plastics. To borrow a current slang expression, in packaging, plastics are what's happening.

The excitement which plastics generate is understandable. These materials are truly new in packaging, a field which has been dominated for many decades by paper, glass, and metals. The appearance of plastics has created a renaissance in packaging: they have initiated round after

TABLE 41.—*Shipments of closures for containers: 1958–1966*

In millions of units

Type of closure	1958	1959	1960	1961	1962	1963	1964	1965	1966
Metal caps	14, 653	15, 419	14, 884	16, 050	16, 570	17, 169	17, 170	17, 950	18, 459
For glass containers	14, 653	15, 419	14, 884	15, 361	15, 747	15, 980	15, 980	16, 761	17, 287
For metal containers	(a)	(a)	(a)	559	623	784	785	792	726
For plastic containers	(a)	(a)	(a)	130	200	405	405	397	446
Metal crowns	44, 175	46, 473	42, 096	43, 967	44, 532	45, 471	46, 455	47, 982	46, 654
Plastic closures	3, 026	3, 014	2, 962	7, 076	7, 688	8, 862	8, 862	9, 510	10, 384
For glass containers	3, 026	3, 014	2, 962	4, 295	4, 522	4, 668	4, 668	4, 972	5, 446
For metal containers	(a)	(a)	(a)	500	638	725	725	861	1, 010
For plastic containers	(a)	(a)	(a)	1, 205	1, 362	2, 284	2, 284	2, 471	2, 728
For metal tubes	(a)	(a)	(a)	1, 076	1, 166	1, 185	1, 185	1, 206	1, 200
Total closures	61, 854	64, 906	59, 942	67, 093	68, 790	71, 502	72, 487	75, 442	75, 497

[a] Not available.

Source: U.S. Department of Commerce, Bureau of the Census. Closures for containers. *Current Industrial Reports*, series M34H(59-13)—M34H(66-13). Washington, D.C., 1960–1967.

round of intense materials competition; they have penetrated many established markets; they have created new packaging outlets for themselves; and they have been combined with traditional materials to improve the latter. Most importantly, however, their full potential seems hardly to have been tapped. They promise new opportunities for producers, converters, and packagers, and they represent competitive threats to all other packaging materials.

How new are plastics? They have been used in packaging since the 1950's. Volume usage did not develop, however, until about 1960, the year when polyethylene prices dropped and this—the most popular—plastic began to expand in volume. Since that time, plastics have grown rapidly. In 1966, 2.2 billion pounds were manufactured for packaging applications, compared with about 736 million pounds in 1958* (Table 42). On a weight basis, plastics still represented only 2.4 percent of total packaging in 1966, which would seem to indicate that the excitement about plastics is much ado about very little. However, tonnage does not tell the whole story: on a dollar basis, plastics held just under 10 percent of all packaging shipments in 1966.

Description of Plastics

Although this does not hold for all plastics, all of the major varieties are derived from a single, prolific petroleum raw material, ethylene. Ethylene is the base for a multitude of intermediate substances and end products, including such things as explosives, detergents, DDT, certain perfumes, and the aspirin tablet. Polyethylene, polyvinyl chloride, and polystyrene are three of the four major plastics derived from ethylene. Polypropylene, the fourth, is obtained from a process by which ethane is produced (Figure 20).

Cellophane is the maverick. This material, usually included with plastics because it is used in the same products and has similar characteristics, is produced in large quantities (395 million pounds in 1966) from wood pulp. This material will be discussed separately below.

All of the large volume plastics are thermoplastics, i.e., they can be heat-softened repeatedly. Small quantities of thermosetting plastics are also used in packaging. These materials—principally phenol-, urea-, and melamine-formaldehyde—can only be molded once; thereafter they

---

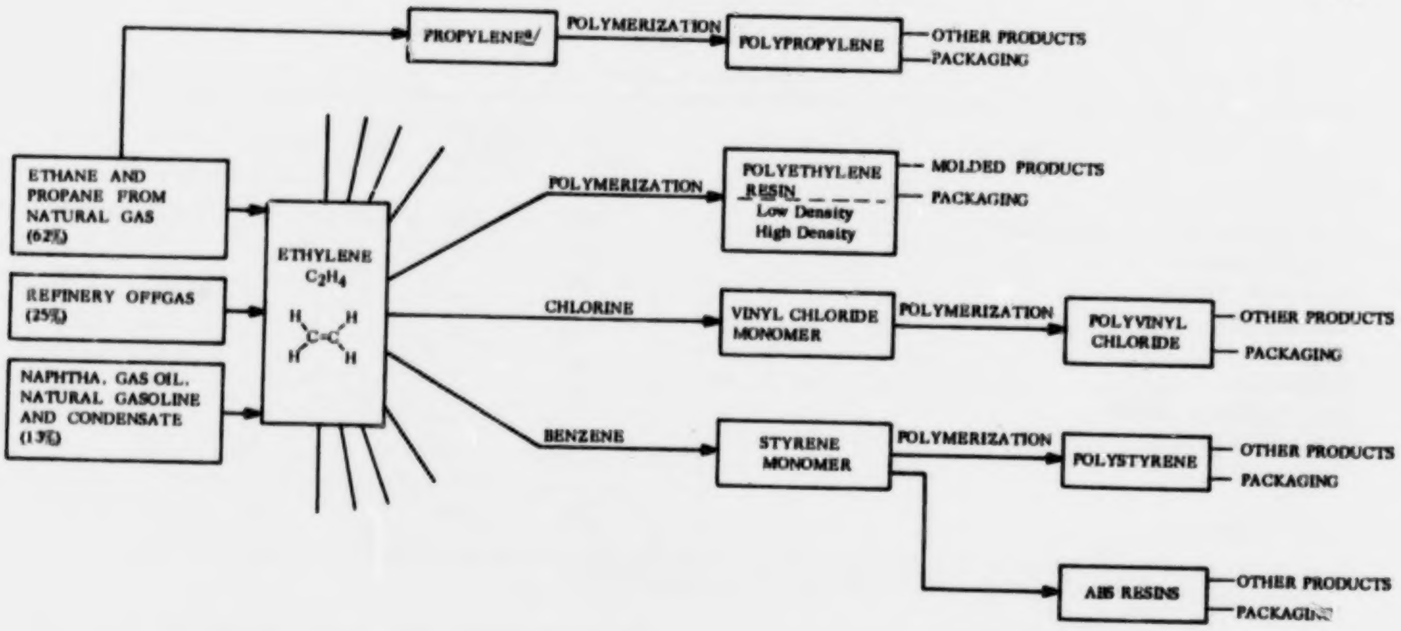
*The figures cited include cellophane, actually not a plastic material in the conventional usage of the term. If cellophane is excluded, 1966 plastics production would be 1.8 billion pounds, up from 333 million pounds, or an increase of 550 percent in eight years.

TABLE 42.—*Consumption of plastics by end use: 1958 to 1976*

In millions of pounds

End use	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976
Rigid and semi-rigid:												
Bottles	23	32	65	125	175	195	227	270	304	730	1,150	1,700
Tubes					(a)	3	3	10	15	30	35	40
Formed and molded	61	73	120	140	175	213	288	375	478	800	1,000	1,400
Closures	22	22	22	53	58	65	66	72	85	120	160	210
Total	106	127	207	318	408	456	584	727	882	1,680	2,345	3,350
Film:												
Cellophane[b]	403	436	439	423	410	405	410	405	395	360	340	320
Polyethylene film	175	247	280	340	380	440	500	615	730	1,280	1,610	2,030
Other plastic film	52	54	57	65	84	104	116	133	192	300	400	560
Total	630	737	776	828	874	949	1,026	1,153	1,317	1,940	2,350	2,910
Plastics total	736	864	983	1,146	1,282	1,405	1,610	1,880	2,199	3,620	4,695	6,260

[a] Not available.
[b] See footnote asterisked above.
Source: *Modern Packaging Encyclopedia.* William C. Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p. *Modern Plastics*, 45(5): 93–94, January 1968. Midwest Research Institute.


PROPYLENE a/
POLYMERIZATION
POLYPROPYLENE
OTHER PRODUCTS
PACKAGING
ETHANE AND PROPANE FROM NATURAL GAS (62%)
REFINERY OFFGAS (25%)
NAPHTHA, GAS OIL, NATURAL GASOLINE AND CONDENSATE (13%)
ETHYLENE
C_2H_4
POLYMERIZATION
POLYETHYLENE RESIN
Low Density
High Density
MOLDED PRODUCTS
PACKAGING
CHLORINE
VINYL CHLORIDE MONOMER
POLYMERIZATION
POLYVINYL CHLORIDE
OTHER PRODUCTS
PACKAGING
BENZENE
STYRENE MONOMER
POLYMERIZATION
POLYSTYRENE
OTHER PRODUCTS
PACKAGING
ABS RESINS
OTHER PRODUCTS
PACKAGING

a/ Most propylene comes from gasoline manufacturing operations.

Source: Midwest Research Institute.

FIGURE 20.—Packaging plastics commonly derived from ethylene

cannot be heat-softened again. Thermosets are used primarily for closures.

The key to the popularity of plastics is their outstanding performance characteristics in packaging applications:

- —They are strong, durable materials which perform well both at high and low temperatures.
- —They may be used as rigid, flexible, or semirigid materials.
- —They can be colored readily and can be produced as clear or opaque containers.
- —They are excellent barrier materials which resist chemicals, oils, greases, and can be made to either transmit, exclude, or contain vapors and gases.
- —Finally, they have many characteristics which favor them in package manufacturing or package filling: they are easy to machine, can be thermoformed, are printed without difficulty, and are heat-sealable.

Given such characteristics, plastics can be produced by a number of techniques, including extrusion, casting, solvent dispersion, fabrication, injection molding, blow molding, thermoforming, compression molding, and cold forming.

Uses

Plastics in packaging are used in three basic groupings: (1) as films and thermoformed and fabricated sheets; (2) as molded containers and closures; and (3) as coatings and adhesives. Coatings and adhesives are discussed under the heading of Miscellaneous Packaging Materials in a separate section. The others are discussed here.

Production volume is fairly evenly divided between films and sheet (922 million pounds in 1966, excluding cellophane) and the more rigid container groupings (882 million pounds). An overview is presented, for 1966, in Table 43. Table 44 shows more detailed breakdowns for 1965, 1966, and 1967.

General Trends

The basic trend which characterizes plastics in packaging is rapid expansion. Underlying the growth of plastics are popular demand by the consumer and technological developments aimed at improving the performance characteristics of these materials by combining them with one another and with other materials.

TABLE 43.—*Plastics consumed in packaging by type of material: 1966*

In millions of pounds

Material	Film and sheet	Formed and molded containers	Bottles and tubes	Closures	Total	Percent
Polyethylene, low and high density	730	95	304	26	1,155	64.0
Polypropylene	58			9	67	3.7
Polyvinyl chloride	60		12		72	4.0
Polystyrene	8	371	3	10	392	21.7
Polyester	8				8	0.5
Cellulosics	30				30	1.7
Polyvinylidene chloride	22				22	1.2
Urea and phenolics				29	29	1.6
Other	6	12		11	29	1.6
Total	922	478	319	85	1,804	100.0

Source: *Modern Plastics*, 45(5): 98, Jan. 1968, Modified by Midwest Research Institute.

Flexible Plastics Packaging

More than 1.3 billion pounds of plastics, including cellophane, were converted into a variety of films for packaging in 1966. Packaging films represented nearly 60 percent of all plastics packaging produced in that year. Overall, this material grouping will enjoy very good growth (8.2 percent annually), resulting in a volume of 2.9 billion pounds in 1976 (Table 45, Figure 21). In that year, however, flexible plastics will represent only 46 percent of total plastics packaging, having been outdistanced by formed and molded plastics which will enjoy much greater growth in the 10-year period of this forecast.

Two broad groupings of flexible packaging can be distinguished: flexible packaging with films and shrink packaging. Separate sections will be devoted to these two types of packaging, followed by sections on polyethylene, other plastics, and cellophane.

Flexible Packaging

On a tonnage basis, flexible packaging is dominated by paper. In 1966 more than 9.4 billion pounds of paper were used in such packaging service versus about 1.3 billion pounds of plastics and cellophane.

Two types of plastic materials—polyethylene and cellophane—are used extensively as flexible films in packaging. Several other types of films also find substantial, if notably smaller, outlets. Among them are: polypropylene, polystyrene, saran, polyvinyl chloride, polyester, polycarbonate, pliofilm, nylon, and cellulose acetate (Table 46 and Figure 22). Most of these films are used either as inner and outer wraps, as bags and envelopes, or as pouches. They may find application either as unsupported film or as laminations to other films, foil, and paper.

The great bulk of films still appears in monolithic form—pure polyethylene, coated cellophane, polyvinyl chloride, and polypropylene. However, an increasing percentage of these films is appearing in specialized forms and in combinations. Over the last few years, simplicity of film design based on monolithic films has given way to a complex array of laminations and multilayer or "structured" films. Today there are more than 500 coated and laminated composites, combining thermoplastics, cellulosics, paper and foil for packaging service. In addition, the traditional distinctions between rigid and flexible packaging are also disappearing.

Underlying the rapid historical growth of plastics in flexible packaging are four forces:

1. The ability to use these materials to package a wide variety of products, combined with a trend toward packaging many items which have not traditionally rated such distinction;

2. Plastic film technology, which is improving the utility of these materials and endowing them with new characteristics;

3. The competitive promise of plastics against such materials as glass and metals, which spurs research effort and experimentation aimed at future market growth;

4. The drop in polyethylene prices mentioned earlier.

TABLE 44.—Plastics consumed in packaging: 1965–1967

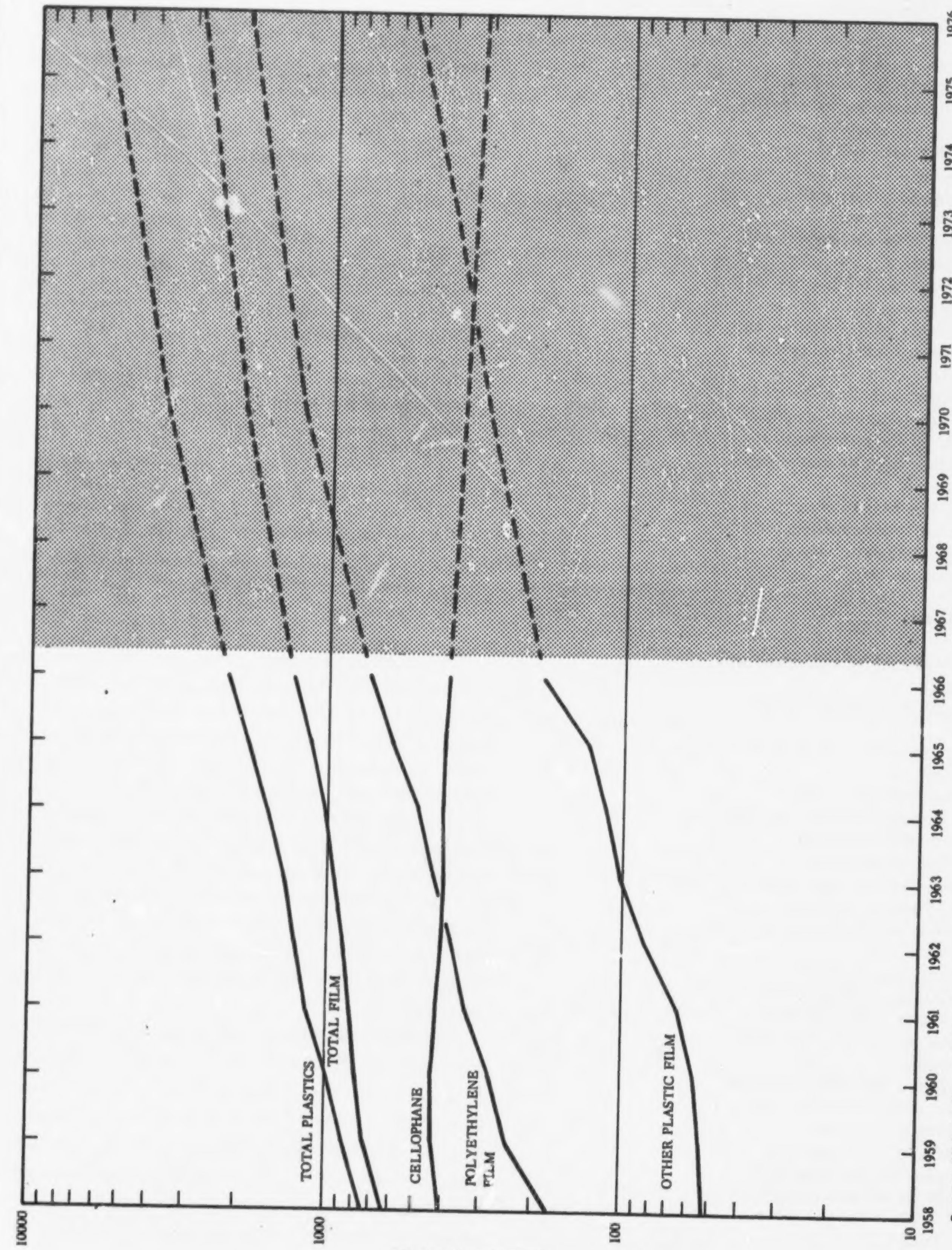
In millions of pounds

Type of plastic	1965	1966	1967
Film and sheet up to 10 mils:			
Polyethylene, low and high density, including industrial packaging, drum liners, garment bags, heavy-duty bags, etc.	615	730	800
Polypropylene (cast and oriented, 75% cast)	40	58	61
Polyvinyl chloride (shrink, cast, extruded)	43	60	70
Unplasticized PVC (mostly for thermoforming)	8	12	15
Polystyrene (film only, sheeting is included under containers)	6	8	9
Polyester	8	8	8
Cellulosics, including skin and blister packaging, film and sheet for thermoforming	16	30	32
Vinylidene chloride (excluding household wrap)	7	10	11
Miscellaneous (including nylon, ionomers, fluorocarbon, polyvinyl alcohol, netting, polycarbonate, etc.)	5	6	7
Total	748	922	1,013
Formed and molded containers and lids:			
Styrenic sheet for thermoforming	105	125	133
Oriented polystyrene sheet for forming	25	30	32
Styrenic molded containers (including such items as cups, berry baskets, cheese containers, lids, etc.; excluding foam and closures)	150	170	172
Foam (styrenic, including general-purpose extruded polystyrene)	25	46	75
Miscellaneous (including cellulosics, methacrylate, urethane; excluding sheet listed under "film and sheet" above)	10	12	13
Polyolefins (including ice cream containers, coffee can lids, beverage cases, etc.; excluding thermoformed containers which appear in total for PE film and sheet)	60	95	100
Total	375	478	525
Bottles and tubes:			
Polyethylene bottles	265	289	350
Vinyl chloride compounds	5	12	22
Other, including PS and acrylic multipolymer		3	8
Collapsible tubes, polyolefins	10	15	20
Total	280	319	400
Closures:			
Urea	16	19	19
Phenolics	8	10	10
Polyethylene, high density	5	10	18
Polyethylene, low density	15	16	16
Polypropylene	6	9	10
Polystyrene	10	10	10
Vinyl plastisol gaskets for jar lids	8	8	8
Vinyl chloride cap liners	2	3	3
Total	72	85	94
Total—all categories	1,478	1,804	2,032

Source: *Modern Plastics*, 45 (5): 43, January 1968. Midwest Research Institute.

The most important recent technological advance in flexible plastics packaging has been the development of techniques for combining various types of films (or other materials) to form composite or structured materials. These packaging composites are actually materials "systems," mating the different characteristics of dissimilar materials to yield a new substance with superior performance. Film structuring is not a new idea, but the technology to combine films is of recent vintage, dating from about 1962. Essentially the method involves extruding films in combinations so that they are intimately bonded during manufacture.

The most promising technique is coextrusion, whereby two or more conventional film extruders feed the film into a common die where various film melts are combined into laminates. Although two- or three-ply films are practical, the method can be used for up to seven-ply combinations. Structured films are also made by combining two or more preformed webs using an adhesive or an



Source: Midwest Research Institute

FIGURE 21.—Consumption of plastic film in packaging: 1958–1976 (millions of pounds)

Table 45.—*Consumption of film in packaging: 1966 and 1976*

Type of film	Quantity (in millions of pounds)		Ten-year rate of change (percent)
	Actual—1966	Forecast—1976	
Cellophane	395	320	−2.0
Polyethylene film	730	2,030	10.7
Other plastic film	192	560	11.3

Source: Midwest Research Institute.

extruded thermoplastic film to effect the lamination. Yet another way in which composites are formed is by depositing a coating, dispersed in a solvent, onto a preformed substrate. When the solvent evaporates or is dried, the coating remains on the substrate.

Whereas monolithic materials have various limitations—cost or performance—composites can be prepared to overcome these at an economical cost. For instance, structured films can be produced to provide barriers to moisture, gases, oils, and chemicals; to give controlled gas or vapor diffusion rates; to resist heat or thermal shock; to be heat sealable at any point between 150 and 600 F; to give stiffness or flexibility; and to provide a material at any point between full transparency and opaqueness.

This type of composite material has also excited researchers and packagers, who see structured materials as potential competitors of glass and steel containers. The excitement rests on some recent developments. For instance, retortable pouches that protect a product as effectively as a steel can are already possible, and structured packaging has already replaced cans for emergency rations in Vietnam.

Before such materials (retortable food containers) will win wide acceptance, many problems need to be solved, and many hurdles must be overcome—development of suitable materials at an acceptable cost, development of suitable converting and filling machinery, counteracting popular preconceptions which would work against plastics in high-barrier, high-protection applications, etc. Work to develop the technology and to market test such packaging products will most likely take place in the 1966 to 1976 period. During this time, however, we do not expect to see significant competitive threats from plastic film composites to traditional rigid containers in utility food goods.

The rapidly developing film technology may be viewed also as a barrier to film marketing in the near future. Packagers are being bombarded with news of film and film combination developments and are asked to evaluate a wide array of proprietary developments by resin producers. Their choices are becoming so extensive, and the film variations are sometimes so small, that the packagers cannot effectively tailor the films to their package requirements without substantial engineering analysis. Thus, they often stick with an

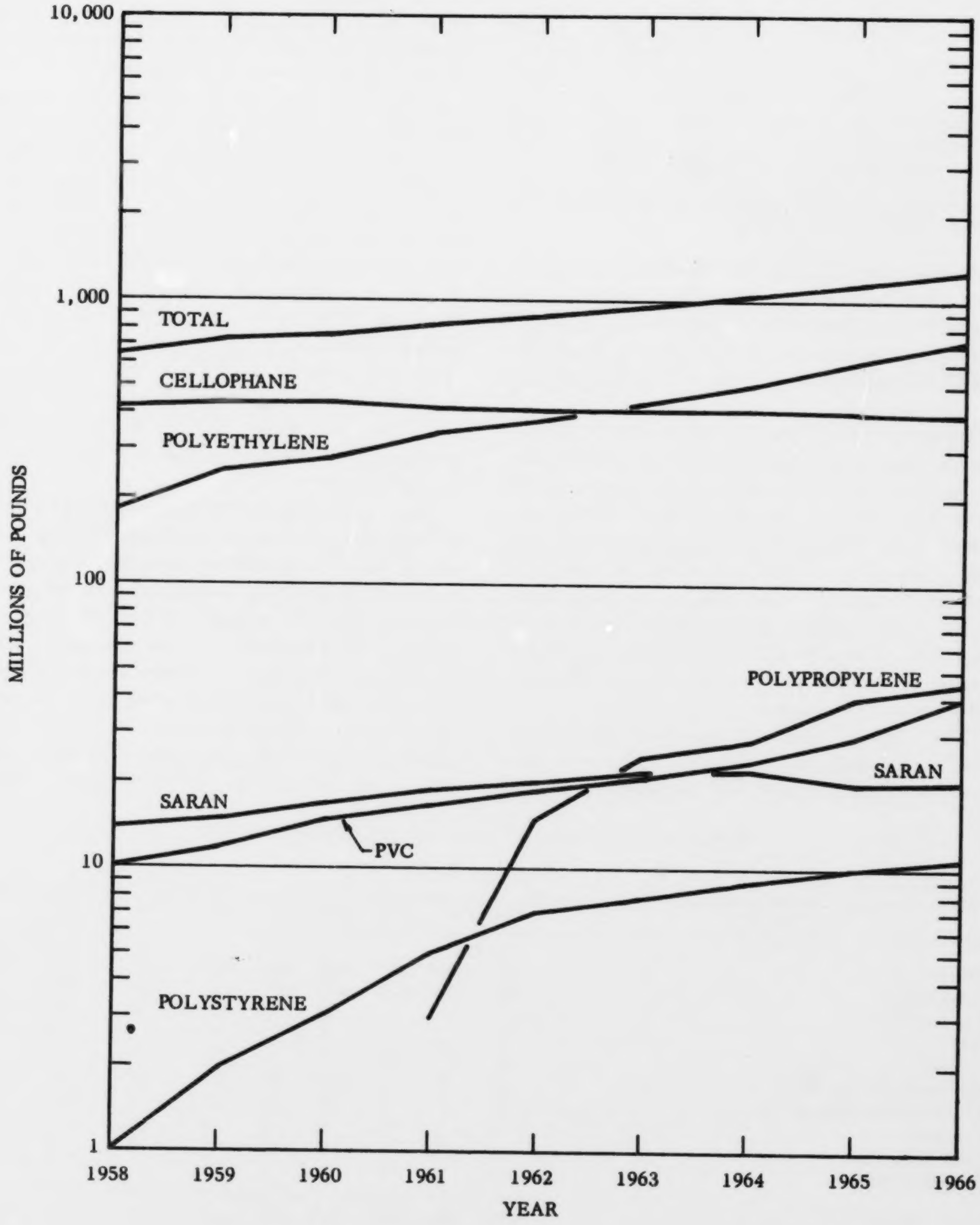
Table 46.—*Films consumed in packaging by type: 1958 to 1966*

In millions of pounds

Type of film	1958	1959	1960	1961	1962	1963	1964	1965	1966
Cellophane	415	436	439	423	410	405	410	405	395
Polyethylene	183	250	272	340	380	440	500	615	730
Polypropylene				3	15	25	28	40	45
Polystyrene	1	2	3	5	7	8	9	10	11
Pliofilm	10	11	12	13	14	15	15	15	15
Polyvinyl chloride (PVC)	10	12	15	17	19	21	24	30	40
Polyvinylidene chloride (Saran)	14	15	17	19	20	21	23	20	20
Polyester	1	1	2	3	4	6	8	8	8
Cellulose acetate	5	5	5	5	5	5	5	5	5
Miscellaneous		1	2	2	3	3	4	4	5
Total [a]	639	733	767	830	877	949	1,026	1,152	1,274

[a] There are minor differences between these totals and Table 41 as a result of adjustments primarily in "other plastic films."

Source: *Modern Packaging Encyclopedia*. William C. Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p. *Ibid.*, Vol. 38, No. 3A. November 1964. 833 p.



a/ The following are not included here: pliofilm, polyester, cellulose acetate and miscellaneous.

Source: Midwest Research Institute.

FIGURE 22.—Films used in packaging: 1958–1966 (millions of pounds) a

established package which has served their purposes well.

A packager must consider not only the characteristics of the material as a package for his products, but also its relative cost, its machine handling characteristics, and the obsolescence time of the package in a period of rapidly changing technology. Thus, while the long-range outlook is for more use of special film designs and combinations, these new developments will be accepted only as fast as packagers can assimilate them; film technology will be running ahead of market acceptance for a few years. This may result in a "shake-out" of materials; certain of the newest types of films and film combinations will probably emerge victorious; others will drop by the wayside. This is not as likely to apply to monolithic films already used in substantial volume as to more exotic combinations.

Shrink Packaging

Plastic films have been used effectively for shrink packaging. In this technique, an oriented or prestretched film is wrapped around a product, such as fresh meat in a tray, which is sent through a heat tunnel. The temperature in the tunnel and speed of the package moving through the tunnel are controlled so that the film heats and attempts to return to its prestretched condition. In so doing, it forms a tight wrap around the product.

A shrink-wrapped package gives a contour fit to unusually shaped products and often increases their storage life and maintains product quality. The tightened film also eliminates wrinkles and looseness and gives a neat appearance and improved display characteristics to the product.

Shrink-wrapped films provide good moisture protection for the product packaged. Controlled gas transmission rates are also possible with shrink packaging; low oxygen transmission films are used for oxygen sensitive products, and films which allow high gas transmission rates are used for such products as fresh fruits, vegetables, and fresh red meats.

Resin consumption for shrink packaging doubled in the 1963 to 1966 period—from 24 million pounds to 51 million pounds (Table 47). There is considerable competition among films for shrink packaging, with polyvinyl chloride, saran, polyethylene, and polypropylene sharing the greatest volumes.

TABLE 47.—*Film consumed in shrink packaging: 1963–1966*

In millions of pounds

Type of film	1963	1964	1965	1966
Polyethylene	4	6	9	10
Polyvinylidene chloride	11	11	11	12
Polyvinyl chloride	5	7	15	20
Polypropylene	([a])	([a])	([a])	4.5
Other	4	5	6	4.5
Total	24	29	41	51.0

[a] Included in "Other."

Source: *Modern Packaging Encyclopedia*. William C, Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p.

Polyethylene film is the lowest cost plastic film available today. It heat seals at low temperature; it makes a good, tough, moisture-proof wrap, bag, or pouch. It has been used in about equal volumes in food and nonfood packaging over the last several years (Table 48).

Machinery requirements can be quite simple; equipment is low in cost. While there have been problems of design for certain products, these have been largely overcome, and shrink package systems are generally available for most applications. One of the most important problems has been to overcome tearing of the film either during the shrink operation or afterwards as a result of small nicks or cuts on the film edge. Another has been that most of the shrink wrap films are too soft to be pushed through the packaging machinery; they have to be pulled through high speed packaging machines or stiffened in some way where pushing them is unavoidable.

Shrink packaging promises to continue to be one of the major growth areas in plastic films in the next decade as shrink characteristics of the films are perfected and more types of food and nonfood products are packaged in films. The greatest volume use is most likely to be in fresh meats and produce. Another area of potential is in shrink-wrapping of packed products for shipment as an alternative to the use of conventional corrugated boxes (see the earlier discussion of shrinkage in the section on containerboard). This innovation is already being used for shipping unfilled soft drink bottles and is being widely tested by some companies for canned foods.

However, at this point it does not appear that shrink-wrapping will displace corrugated in substantial volume.

Table 48.—*Polyethylene film consumed in packaging by end use: 1961–1966*

In millions of pounds

End use	1961	1962	1963[a]	1964	1965	1966
Food packaging:						
Candy	10	11	13	15	16	20
Bread, cake	30	55	57	60	80	85
Crackers, biscuits	1	1	3	5	5	8
Meats, poultry	5	7	10	12	16	20
Fresh produce	95	100	112	125	145	160
Snacks	1	1	1	2	2	2
Noodles, macaroni	5	5	5	6	6	7
Cereals	2	2	3	3	3	4
Dried vegetables	5	5	6	8	8	10
Frozen foods	5	7	10	12	14	19
Dairy products	1	1	5	7	8	12
Other foods	10	15	10	5	7	13
Frozen food bags, household wrap	10					
Total food uses	180	210	235	260	310	360
Nonfood packaging:						
Shipping bags, liners	40	45	58	70	80	95
Rack and counter				35	40	50
Textiles	35	35	40	45	60	90
Paper	15	15	17	20	25	30
Laundry, dry cleaning	35	35	42	50	60	75
Miscellaneous	35	40	48	20	40	30
Total nonfood uses	160	170	205	240	305	370
Total packaging uses	340	380	440	500	615	730

[a] 1963 Estimated by Midwest Research Institute.

Source: *Modern Packaging Encyclopedia*. William C. Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p. *Ibid.*, Vol. 39, No. 4A. December 1965. 863 p. *Ibid.*, Vol. 38, No. 3A. November 1964. 833 p.

Polyethylene Films

Polyethylene film (predominantly low density polyethylene) has led all plastic films in flexible packaging end uses. Consumption rose from 175 million pounds in 1958 to 730 million pounds in 1966, an increase of over 400 percent in eight years. Polyethylene passed cellophane in 1963 in quantity used and has since left this traditional material far behind.

One of the significant factors about polyethylene film (and other plastic films for that matter) is that its growth as a packaging material has been in two directions. First, it has competed directly with cellophane and paper for existing applications. Second, it has opened up entirely new packaging markets for itself and is used on products that were previously either not packaged or were packaged in larger aggregations. Examples are the use of film for fresh produce, meat, and textile products packaging. Polyethylene is used also as a laminated material and as a liner for barrels, drums, and shipping sacks.

Polyethylene (PE) will continue to be the dominant plastic in flexible packaging in the 1966 to 1976 period. The basic resin technology is well established; production methods are well developed and equipment is readily available. Additional factors which will support PE in its dominant position will be the appearance of new types of polyethylene films for packaging applications—"oriented" films for shrink packaging and "crosslinked" films for meats and other products requiring special characteristics. Furthermore, polyethylene will be the most popular substrate or prime segment material of structured or layered film combinations, thanks to its low cost. The greatest volume will continue to be in monolithic form, however.

PE has enjoyed rapid growth in both food and nonfood packaging (Table 48). Bulk shipping containers (bags, sacks, barrels, pallet bins, etc.) are also often lined with polyethylene. The development of substantial volume in shrink wrapping for utility canned goods or in household waste disposal bags is not expected in the period of this forecast.

On the basis of the foregoing, we foresee an increase in PE production for flexible packaging to 2.0 billion pounds by 1976, up from 730 million pounds 10 years earlier. Growth between 1966 and 1970 will be even more rapid; PE production should reach 1.3 billion pounds by 1970. Thus, beyond the early 1970's, we expect a slowdown in the rate of growth for polyethylene film.

Other Plastic Films

In addition to polyethylene, a large number of other plastic films are also used in specialized packaging applications in flexible packaging. About 192 million pounds of such plastics were used in 1966, up from 52 million pounds in 1958 (Table 45), showing that polyethylene is not the only fast-growing plastic in flexible packaging materials. The most important of these "other" plastics are polypropylene—45 million pounds; vinyl—40 million pounds; and polyvinylidene chloride (Saran)—20 million pounds.

An important use of these films is in shrink packaging of such food staples as meat and produce. They are also used in structured films, again primarily for foods, and in a variety of wrappers and bags.

The outlook for "other plastics" is favorable. Overall, these films should grow from a 1966 base of 192 million pounds to 560 million pounds by 1976. This growth will be primarily in specialty applications to package sensitive foods such as meats, snacks, cheese, produce, etc., and other packaging where the superior strength, barrier properties, and appearance of these more expensive plastics will make them the preferred choice over dominant but low cost polyethylene, cellophane, and paper.

Cellophane

Although it is usually included with plastics in any discussion of flexible packaging, cellophane differs from plastics in basic chemical makeup. Most plastics are hydrocarbons. Cellophane is regenerated cellulose derived from wood pulp. It is one of the few materials which is produced almost exclusively for packaging. It is commonly used as a transparent wrapping or bag material for food products such as baked goods, meats, snacks, and candy. Its largest and most familiar nonfood application is as the cellophane outer skin on cigarette packages (Table 49).

Virtually all cellophanes are coated to make them moisture-proof and/or heat sealable. Principal coatings are nitrocellulose, polyvinylidene chloride, vinyl copolymer, and polyethylene.

Cellophane costs 63 to 81 cents per pound or from 2.9 to 5.8 cents per 1,000 square inches; prices vary depending on material thickness and type. Compared to polyethylene film, selling for 1.1 to 1.3 cents per 1,000 square inches, cellophane appears to be a high cost material; actually, it is quite competitive with other materials (Table 50) as well as with polyethylene if all factors are taken into consideration.

TABLE 49.—*Shipments of cellophane by end use: 1962–1969*
In percent of shipments by weight

End use	1962	1963	1964	1965	1966
Baked goods	33	30	28	25	20
Meat	15	20	20	17	15
Tobacco	10	10	10	13	15
Snacks	10	12	12	11	15
Candy	10	10	10	8	8
Other foods	7	8	9	14	17
Nonfoods	15	10	11	12	10
Total	100	100	100	100	100

Source: *Modern Packaging Encyclopedia*. William C. Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p. *Ibid.*, Vol. 39, No. 4A. December 1965. 863 p. *Ibid.*, Vol. 38, No. 3A. November 1964. 833 p.

Cellophane continues to be a popular material for three reasons: first, it is highly machineable; it is possible to process cellophane at much higher speeds than plastics; this fact serves to overcome some of its price disadvantages; second, it is a highly uniform material available in a wide variety of types (about 120); finally, it has high,

TABLE 50.—*Representative 1967 prices of selected packaging papers, films, and foils* [a]

Material and trade designation	Film cost ($/lb)	Cost/ 1,000 sq. in. (¢)
Cellophane, MS [b] 220	$0.64	2.9
Saran coated MS 140	.81	5.8
Polyethylene coated, 182	.77	4.2
Polyethylene:		
Low density, 1 mil	.32	1.1
High density, 1 mil	.36	1.2
Heat shrinkable, 1 mil	.39–1.00	1.3–3.3
Polypropylene, cast, 1 mil	.59	1.9
Polystyrene, oriented, 1 mil	.63	2.4
Polyethylene-cellophane, 1 mil/195 MS	1.05	8.9
Saran, 1 mil	1.08	6.6
Polyvinyl chloride, extruded, 1 mil	.55	2.6
Cellulose acetate, extruded, 1 mil	.74	3.4
Glassine, bleached, 25 lb	.26	1.5
Pouch paper, coated MS 25/29	.52	3.5
Waxed paper, bread wrapper, 39 lb	.23	2.1
Aluminum foil, 0.00035 in	.64	2.2
Aluminum foil, 0.001 in	.56	5.5

[a] Prices are based on standard or basic materials and large orders. Many variations exist for grades, type, gauges, combinations, and prices.
[b] MS indicates moisture proof and heat sealing properties.

Source: *Modern Packaging Encyclopedia*. William C. Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p.

sparkling transparency, which favors it in uses where good appearance of the package is desired.

Despite these advantages, cellophane use in packaging has been slowly declining. Production in 1966 was 395 million pounds, down from 439 million pounds in 1960. This material has been giving way to monolithic plastics and combinations of plastics as the producers of these materials have developed flexible packaging which duplicates cellophane properties at competitive costs.

The decline of cellophane in packaging should continue for some years to come as competing products are improved, gain in volume, and decline in cost. We expect the decline to be taking place at a rate of 2 percent per year, resulting in a 1976 production of 320 million pounds.

Molded Plastic Containers

Plastic materials weighing 882 million pounds were converted into molded plastic containers in 1966. These containers are generally rigid or semi-rigid. The basic configurations are: bottles; formed containers such as blister packs, tubs, trays, plastic foam products, and the like; tubes; and plastic closures.

On a tonnage basis, formed containers represented the bulk of total consumption in 1966 in this area or 54 percent, followed by bottles (34 percent), closures (9 percent), and tubes (3 percent). By 1976, the relative dominance of these configurations will have changed somewhat, with bottles taking on the lead, formed containers having dropped to second place (Table 51, Figure 23).

TABLE 51.—*Consumption of formed and molded plastics by type: 1966 and 1976*

Type of container	Quantity (in millions of pounds)		Ten-year rate of change (percent)
	Actual—1966	Forecast—1976	
Formed and molded containers ᵃ	478	1,400	11.3
Bottles	304	1,700	18.8
Closures	85	210	9.5
Tubes	15	40	10.3
Total	882	3,350	14.3

ᵃ Includes plastic forms.

Source: Midwest Research Institute.

Each basic configurational category will be discussed in detail below. Plastic foams, although usually included under formed containers, are discussed separately, so that the special characteristics of this application area can be treated more adequately.

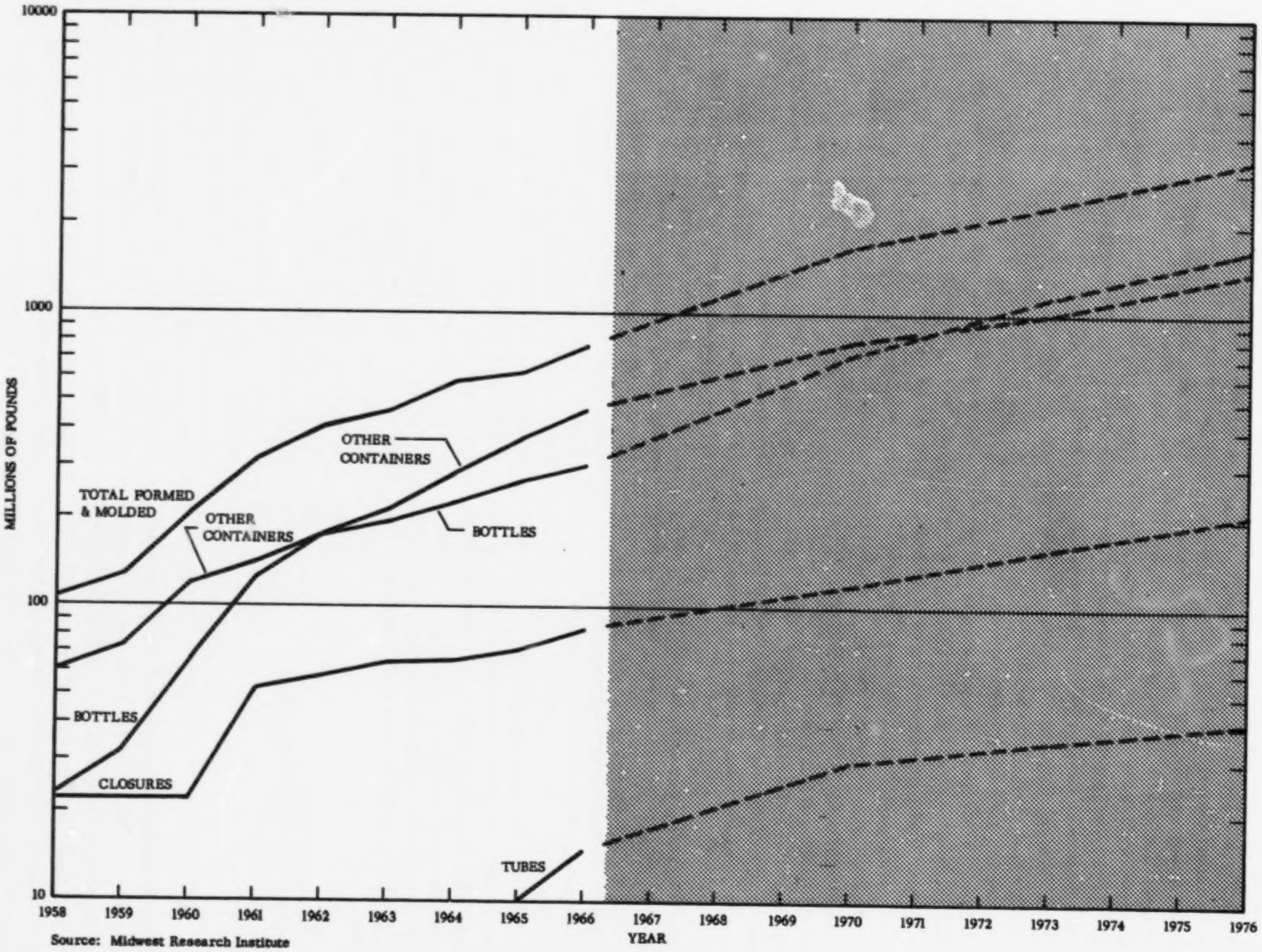
Formed Containers

Formed and molded containers have been quite successful and have enjoyed the high growth rates of other plastics in packaging. From 1958 to 1966 the consumption of plastics in formed packaging rose from 61 million pounds to 478 million pounds—an increase of 780 percent in the period (Table 42).

Formed containers are usually produced from sheet material by thermoforming. In this process, heated sheet materials are shaped by mechanical pressure and/or air pressure into a die to give the material a specific configuration. More recently, cold forming techniques have also been applied successfully to certain types of plastic sheet.

There are several common formed and molded configurations. One of these is the blister packs in which plastic sheet forms a pocket around a product. The pocket is preformed and then sealed to a paperboard backing after filling. (A form related to this is skin packaging in which the plastic, usually film, is shaped to the contours of the product and is then tightened by shrinking to hold the product tightly.) Another common configuration category is open mouth boxes, tubs, and baskets for cottage cheese, margarine, berries, and so forth. Usually, the lids for these containers are made of formed plastic also. Trays and inserts are produced also from formed plastics. These items are most familiar as meat trays, vending machine trays, and inserts to fit injection molded containers. They also show up as disposible items in hospitals, restaurants, schools, and other institutions.

Formed containers are low in cost, often competitive with pulp and paper; permit high production speeds on relatively simple equipment; provide good product protection; and are effective merchandising tools. Formed containers, especially blister packs, are used to package many items which were shelved without packaging in the recent past. Formed packages have the rigidity



Source: Midwest Research Institute

FIGURE 23.—Consumption of formed and molded plastics in packaging: 1958–1976 (millions of pounds)

and display features of folding cartons, the light weight and low cost characteristics of pouches. They are usually transparent, and can be decorated readily for display purposes.

The dominant material used for formed plastic containers is polystyrene. In its diffierent forms, it accounted for nearly 80 percent of the total plastics used in formed and molded containers in 1966. (This category excludes bottles.) Polystyrene is preferred because of its relatively low cost, good forming characteristics, and excellent performance as a package material.

Most forming technology is based on forming heated sheet by vacuum or pressure (or a combination of these) to achieve the package shape desired. Sheet thickness ranges from 4 to 40 mils. Thermoforming molds are relatively low in cost in comparison with injection molds and, therefore, thermoforming is usually favored where it can be used. Considerable scrap is produced during the thermoforming process, and many converters augment their sheet purchases by using their own extrusion equipment and recycling the scrap.

Recently there have been advances in forming technology which improve the methods of heating and cooling the plastic sheet and also permit automation of thermoforming sequences.

Although polystyrene is the dominant material used at present, other plastics are receiving increased attention. One application where other resins already compete with polystyrene is in packages for soft margarine, a food product that has become very popular in the last two years. An estimated 650 million half-pound tubs were sold in 1967, with a material breakdown as follows:

	Million units
High density polyethylene	400
Acrylonitrile butadiene styrene (ABS)	160
Acrylic multipolymer	30
Aluminum	60
Total	650

These containers are typical of the "deep draw" type, now possible in formed plastics, and represent significant competition in a field which has been the traditional preserve of paperboard.

Acrylonitrile butadiene styrene (ABS) has attracted considerable attention recently because it can be cold-formed on metalworking machinery to yield a package of uniform wall thickness, high impact strength, and good stress-crack resistance.

Polyethylene, because of its relatively low price and good forming characteristics, is also becoming a significant factor in formed plastics.

Outlook: There is considerable activity in forming and fabricating technology of plastic sheet materials. New approaches are under development—for example, continuous processing from resin to finished product—which promise considerable production versatility at low cost. Unfortunately, the information available about new technology in this area is quite sketchy, since these are proprietary developments not yet secured by patent positions. Individual companies have not publicized their activities for competitive reasons. Our industry contacts indicate, however, that these developments will be of significant impact and will have considerable packaging potential, particularly in competition with present paperboard packaging.

Targets of these new forming developments are package markets now held by paper and paperboard. The recent success of plastics in dairy products, for example, is only one area in which plastics will be much more competitive in future years. Other food products, of course, have been and will continue to be the competitive goal of formed plastics. Nonfood products are also getting considerable attention. For example, fabrication of shipping containers to replace corrugated paperboard has recently been introduced (in addition to shrink wrap already discussed). This is done by using conventional box-making techniques; reusable as well as single-use containers can be made in this way. While cost is a major deterrent at present, this type of formed and fabricated container is representative of the many possibilities which exist in nonfood packaging.

Styrenes and polyolefins will be used in the greatest volume in the future. Although styrenes now account for about 80 percent of the consumption, they will likely take a somewhat smaller share of the total in the future as the polyolefins are adapted to formed and molded applications. In addition, there will be continued use of other types of materials such as urethanes, cellulosics, and methacrylates; none of these, however, appear to be headed for substantial volume use.

On a quantity basis, we expect consumption of formed plastic containers of 1.4 billion pounds of resins in 1976, corresponding to an annual growth rate of 11.2 percent for the period.

Plastic Foams

The forecasts given for formed and molded containers include plastic foams, which have been used in an increasing array of applications in recent years and have become familiar in plastics packaging. The reasons may be found by listing foam characteristics which have made them adaptable to package applications. Foams have:

—Low density—in the range of 1 to 30 pounds per cubic foot. While foam packages are usually somewhat bulky, they have good strength-to-weight ratios and usually weigh less than equivalent conventional materials such as wood or containerboard;

—Shock absorbency (or energy absorbing) capability;

—Good thermal insulation properties; and

—Chemical inertness and low water absorbency.

The resins commonly used for plastic foams in packaging are polystyrene, polyurethane, and polyethylene. Two other materials—styrene acrylonitrile and polyvinyl chloride—have also been used in very limited quantities. By far the most common today are the styrenic foams which accounted for about 10 percent, 46 million pounds, of formed and molded plastics in 1966, compared with 8 million pounds of polyurethane. The polystyrene foams are generally favored because they are much lower in cost than other foams and are adaptable to a variety of packaging applications.

Foams may be formed by molding, by fabrication from slabs, and by thermoforming from sheet. They are also combined with other materials like paper, paperboard, and other plastics by laminating.

Probably the most familiar foam products are packaging components such as molded shapes to protect fragile instruments, machined parts, glassware, and military hardware; cushion inserts; pads, and loose fill or dunnage. However, foams are also used for cups, trays, shipping crates, and other types of containers. For example, meat trays—used at the rate of about 9 billion units per year—were long the exclusive domain of pulp and paperboard. In 1966, thermoformed polystyrene foam trays accounted for about 18 percent of the unit volume and were expected to take up to one-third of this market by 1968.

Despite often optimistic forecasts for plastic foams in packaging, they have not been adapted to packaging applications as rapidly as predicted. The technology of forming is relatively well developed. However, there has been a lack of balance between foam supply, processing equipment, and molding capacity. Also, peripheral techniques such as printing and labeling have only recently become available on the cost basis needed for competitive purposes. In foam sheet production, there must be a fairly high degree of process integration because thermoforming produces considerable scrap. This scrap must be recycled to minimize disposal costs and raw materials losses; this has discouraged manufacturers from setting up in-plant packaging machinery; conversely, foam sheet extruders have been reluctant to get into consumer package fabrication.

In addition to these problems, the packaging industry has had no compelling reasons to utilize foams extensively. And foam producers have not gone directly to packaged product buyers to sell the virtues of foam packing and packages.

One of the significant support areas has arisen from a package specifying source within the government—where military packaging has been evaluated for performance and cost. In one case, for example, the Packaging Development Division, U.S. Naval Ammunition Depot, has specified polystyrene foam for certain munitions packaging after extensive testing and evaluation.

Foam packaging is commonly predicted to double in volume in the next five years. This is not at all unlikely since this advance would be from a relatively small base. Furthermore, rapid acceptance in a few applications would add to the volume significantly. For example, complete domination in meat and produce trays would require nearly 200 million pounds of polystyrene foam a year. Egg cartons and fresh produce shippers are other products likely to be made of foam plastics in the years ahead.

The price relationship among foams is likely to remain much the same in the foreseeable future as it is today; thus, polystyrene will continue to be used in greatest volume while polyurethane, polyethylene, and other foams will be used in specific situations where their performance characteristics are superior. With the basic foam technology well developed, the next steps will be in the direction of production sequence integration.

We did not attempt to distinguish volume usage of foams within the formed and molded container category. However, assuming that they will continue to have about the same share in the future, foam consumption should reach between 150 and 200 million pounds in 1976.

Plastic Bottles

Plastic bottle production soared from 1.1 billion units in 1960 to an estimated 3.1 billion units in 1966. This dramatic increase was accompanied by rapid changes in bottle-making technology and in end-use markets.

Polyethylene: High density polyethylene (HDPE) is the dominant resin used for bottles today (88 percent by weight in 1966). HDPE reached significant volume when it was introduced for household bleaches and liquid detergents in 1958. Since then, this material has also been used to package various drugs, cosmetics, and toiletries, and has gained a small foothold in milk and foods packaging as well.

High density polyethylene has very good resistance to impact, chemicals, alcohols, and water vapor. It is limited in some applications because it is permeable to oxygen and oils and is not available in crystal-clear form. Although the price of PE bottles has increased recently, HDPE remains the lowest cost resin for blow-molded bottles. The long-term historical trend to lower resin prices for bottle grade HDPE has been from 44 cents per pound in 1958 to a relatively stable 20 cents per pound in 1967.

Machinery technology has kept pace with resin technology, so that today many proprietary PE formulations can be blow-molded on equipment which is readily available. However, a good deal of equipment is custom designed for specific applications; and in fact, the development of packaging "systems" has been an important factor which has enabled resin producers and packaging companies to successfully enter new markets. Conversely, the need to develop new in-plant filling equipment has slowed the growth of PE bottles. One company recently reported, for example, that the polyethylene milk bottle market has grown slower than first anticipated. Reason: It has been necessary to develop special volumetric filling equipment to replace the filling equipment already available in most dairies for carton or milk bottle filling; PE bottles cannot be filled without major change of existing systems.

Polyvinyl Chloride: The Cinderella resin for a number of years, PVC now appears on the threshold of a breakthrough into molded bottle markets. In 1966, PVC consumption for bottles rose to about 12 million pounds of resin from a total of 5 million or less the previous year! Resin consumption probably doubled again in 1967.

PVC is potentially the "ideal" material to compete with glass. It can be made in rigid, impact-resistant, crystal-clear form. It has good chemical resistance to alcohols and oils, low permeability to water vapor and gases, and is opaque to ultraviolet light. The basic resin is available in large quantity because it is widely used for a variety of non-packaging products, ranging from floor coverings to garden hoses and raincoats. (More than 2 billion pounds of PVC were sold in 1966 for non-packaging applications.) The cost of unmodified PVC is about the same as that of bottle grade HDPE (20 cents per pound). However, the modifiers required for PVC bring the cost to about 30 to 33 cents per pound after compounding.

PVC is blow-molded in its rigid (unplasticized) form. For blow-molding, additives are needed, otherwise the resin would decompose before it would melt. The ideal formulation, to date, incorporates stabilizer chemicals that give clarity, stiffness, strength, and meet Food and Drug Administration requirements for food products. Modifier chemicals which achieve one property may cause deterioration of another. For example, modifiers which give the high strength and impact resistance desired may leave the finished product somewhat cloudy or hazy; a crystal-clear formulation may lack the strength or barrier properties needed.

FDA approval has been given for a propylene-modified PVC resin for foods. Dioctyl tin, however, is the modifier which producers hold out as the compound able to give both the strength and clarity desired. The major drawback of dioctyl tin is that it influences the product taste; another is that a heavy metal is potentially a toxicity risk. Nonetheless, several compounds have been submitted to FDA for approval for food products and FDA approval for one company's dioctyl tin modifiers was granted in very early 1968.

The most likely candidates for PVC packaging in food are vegetable oils, vinegar, wine, salad dressings, and seasoning products. Nonfood products include toiletries and cosmetics (hair lotions, mouthwashes, shampoos, etc.) and chemicals such as household cleaners.

Some packaging companies have a large stake in PVC, and volume production is expected to develop in both food and nonfood applications in the next few years. A series of interrelating technologies will be combined to bring about acceptance of PVC. This includes the combination of complex formulations, molding techniques, machinery design, and product/package performance characteristics.

Since polyethylene has led the way in molded plastic bottles, the existing blow-molding technology has aided other resins used for bottles, for instance, polystyrene. Some resins, however, cannot be formed on PE equipment; one of these is PVC. Most of the PVC blow-molding capacity is in the form of proprietary in-plant machinery owned by major resin suppliers. Assuming that PVC is accepted in food packaging applications on a limited scale, exploitation of the potential will have to await availability of machinery to turn out the billions of units which might be demanded. Thus, in the short run, lagging forming technology may delay PVC acceptance on a wide scale; but in the long run PVC should establish itself as second only to polyethylene in the bottle field.

Polystyrene and Polypropylene: Polystyrene has recently been used for bottling analgesics and bouillon cubes. This plastic is clear, rigid, and has a high heat distortion temperature. It has relatively poor barrier properties compared to other plastics, however, but will likely find increased use in products which do not require a high degree of water, gas, and oil resistance.

Polypropylene is another promising material for bottles, being potentially competitive with both HDPE and PVC. It has high impact strength, stiffness, durability, chemical resistance, good barrier properties, and good clarity; but it is more costly than high density polyethylene. Comparative data for the various resins used in bottles are given in Table 52.

Outlook: In general there will be continued spectacular growth in the number of plastic bottles used. From a materials standpoint there will be a variety of proprietary resin formulations available, designed for specific performance requirements. In addition, long-term price trends will favor plastics vis-a-vis other materials. For example, long term supplies of ethylene, the basic source of polyolefins, are usually obtained under a negotiated contract and are based on long-term raw materials supplies. The capacity of some new plants being built is in the range of 500 million pounds annually, and packagers are able to enter raw material contracts or assure themselves of captive capacity at relatively stable raw material prices.

Bottle production technology will continue to depend partly on proprietary machinery design and packaging "systems" for specific product applications. Resin suppliers and packaging companies have supplied much of this technical service to achieve entry into the specific markets. While some machinery technology deficiencies will develop as large volume markets open up to plastics, they will not retard the overall expansion of plastics in volume production.

In some cases, new marketing approaches will be used by companies to introduce new products. For example, one company is using a "pay as you package" approach in marketing returnable plastic milk bottles. In this plan, the bottle buyer is not required to make the substantial capital investment in equipment required to change over from glass to plastic bottles. Instead, the bottle supplier provides the entire packaging system and charges the dairy a single fixed charge per unit filled.

To determine the extent to which plastic bottles would be used in 1976, we attempted to establish the most probable volume by end use, taking into consideration both the competitive factors and technological advances likely to take place during the 1966 to 1976 period. In general, however, high density polyethylene resin formulations will continue to dominate materials; PVC is expected to gain substantial volume in the next few years. By 1976, total resin consumption for bottles should rise to 1.7 billion pounds compared with 300 million pounds in 1966. Of the 1976 production, high density polyethylene will account for 1.1 billion pounds, PVC for 300

TABLE 52.—*Resins for bottles—comparative data*

Resin	Resin price—$/lb [a]	Advantages	Limitations	Major uses
High-density polyethylene.	$0.18 Bottle prices: $/M. 4 oz. capacity $27.50. 16 oz. capacity $43.10. 32 oz. capacity $65.00.	Toughness; low water vapor transmission; good chemical resistance; FDA approval.	Permeability to oxygen and oils.	Detergents, bleaches, cleaning powders, industrial products, milk and foods.
Low-density polyethylene.	.18 Bottle prices: $/M. 4 oz. capacity $39.50. 16 oz. capacity $86.00. 32 oz. capacity $140.00.	Low price; good molding properties; impact resistance; low water and alcohol transmission; flexibility; FDA approval.	Permeability to oxygen and oils; attacked by some chemicals.	Cosmetics and other personal care products.
Polyvinyl chloride (PVC).	.29 Bottle prices: $/M. 4 oz. capacity $42.50. 12 oz. capacity $63.00. 16 oz. capacity $84.00.	Clarity; toughness; stiffness; good barrier properties.	Low heat distortion temperature; molding conditions must be controlled carefully; resin additives can influence product quality; limited FDA approval.	Foods: juices, syrups, oils, dressings, pickles, vinegar, peanut butter; shampoos, bath oils, detergents, waxes, drugs, chemicals.
Polypropylene copolymer.	.19	Toughness; good barrier properties; moderate clarity; heat resistant; FDA approval.	Barrier properties poorer than PVC.	Potential: foods, motor oils, medicinals, toiletries.
Polystyrene	.15	Rigidity; toughness; high heat distortion temperature; FDA approval.	Permeability to water, oxygen, oils; poor resistance to chemicals.	Dry products, such as aspirin, bouillon cubes; dry drugs; petroleum jelly.
Acrylic multipolymer.	.45	Clarity; toughness; rigidity; good resistance to oils and oxygen; FDA approval.	High price	Foods, drugs, cosmetics.
Ionomer	.47	Clarity; good grease and water barrier; excellent impact resistance; FDA approval.	High price; difficult to mold	Potential: cosmetics, personal products, foods.

[a] These are representative 1967 prices for clear or natural grades. Actual prices vary widely according to the type and grade of resin used. Bottle prices vary widely also depending on size, shape, design, quantity, product, container performance, etc. Prices for polyethylene bottles are generally competitive with glass in large quantity orders.

Source: Compiled by Midwest Research Institute.

million, and other resins such as polystyrene, polypropylene, acrylics, ionomer, and phenoxy, for another 300 million pounds (Table 53).

Specific end-use markets are discussed next. Plastic bottle production for these markets is shown in Table 52.

Chemicals: The overwhelming number of plastic bottles used to package chemicals will continue to be high density polyethylene; however, PVC will show a significant volume increase in the next decade for certain household chemicals such as cleaners and wax.

The markets for plastic bottles for household and industrial chemicals are maturing now and are not expected to grow rapidly in the next decade. The primary reason for this is that the markets for plastic bottles in household bleaches and liquid detergents are nearly saturated.

Automotive Packaging: In the automotive and marine categories, substantial growth will take place as high density polyethylene and polypropylene enter volume production for one quart motor oil containers. We expect plastics to capture 40 percent of total units shipped by 1976. In this area, plastics will displace a considerable portion of paper composite cans; these have about 60 percent of the unit volume today; the balance is held by steel. Even this optimistic estimate for plastics in oil packaging could be somewhat low if material costs come down more rapidly in relation to steel and paper composites.

Although polypropylene is suitable for some foods and nonfoods, perhaps its greatest promise is in motor oil cans. So far, problems of cost and can strength (rigidity) have kept plastics out of oil packaging, except for premium products. However, an extruded polypropylene can has recently been developed. The can is stiff, and can be produced rapidly.

Another factor which will favor plastics in oil is that major petroleum companies have captive resin capacity; some companies also operate packaging divisions. As the cost differential between plastics and composite and steel cans narrows, these companies will be the first to make the switch to plastics.

TABLE 53.—*Shipments of blow-molded plastic bottles by end use and resin: 1960 to 1976*

In millions of units and millions of pounds

Classification	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976
Bottles by end use:										
Household and industrial chemicals	(a)	(a)	(a)	1,351	1,549	1,659	1,740	[b] 2,360	[b] 2,680	[b] 3,000
Bleach				(a)	(a)	513	504			
Detergent, liquid				(a)	(a)	813	802			
Dry cleaners, other				(a)	(a)	333	434			
Industrial chemicals and specialties	(a)	(a)	(a)	58	69	106	151			
Automotive and marine	(a)	(a)	(a)	(a)	26	24	25	700	1,000	1,500
Medicinal and health	(a)	(a)	(a)	142	143	265	288	540	810	1,100
Food	(a)	(a)	(a)	[c] 22	[c] 51	[c] 91	[d] 65	[d] 700	[d] 4,200	[d] 1,770
Milk, liquid	(a)	(a)	(a)	(a)	(a)	(a)	74	1,400	2,940	6,140
Toiletries and cosmetics	(a)	(a)	(a)	416	525	579	769	1,480	2,500	3,430
Total units	1,100	1,700	2,100	1,989	2,364	2,723	3,112	7,180	11,130	16,940
Resin by type:										
Polyethylene	65	130	170	194	223	262	289	550	800	1,100
PVC	(a)	(a)	(a)	(a)	(a)	(a)	12	125	210	300
All other resins	(a)	(a)	(a)	(a)	(a)	(a)	3	55	140	300
Total pounds	65	130	170	195	227	270	304	730	1,150	1,700

[a] Not available.
[b] Total household and industrial chemicals.
[c] Includes milk.
[d] Excludes milk.

Source: U.S. Department of Commerce, Bureau of the Census. Plastic bottles. *Current Industrial Reports*, Series M30E (61-13)–M30E(65-13). Washington, D.C., 1962–1966. *Modern Packaging Encyclopedia.* William C Simms, ed. Vol. 39, No. 4A, New York, McGraw-Hill, Inc. December 1965. 863 p. Forecasts by Midwest Research Institute.

Medicinals: The number of plastic bottles used for packaging medicinal and health products is expected to quadruple by 1976, from 288 million to 1.1 billion units. Plastics will displace glass in many applications. The favored resins will be PVC and high impact polystyrene. We expect that plastics will capture about one-fourth of the total 1976 unit volume for glass and plastics in medicinal and health products.

Foods: The use of plastic containers for foods and beverages has been modest to date (65 million units in 1966). However, we expect that the recent FDA approval for tin-modified PVC will open up opportunities for PVC in food where polyethylene and polystyrene have been unable to achieve significant volume usage. And, while we do not foresee widespread use of plastics for food products, food applications will account for nearly 1.8 billion units in 1976. PVC now appears to have the greatest opportunity in packaging liquid cooking oils, seasoning products, syrups, pickles, and the like. New advances in resin technology could bring other resins into volume use in food packaging; among them are polyethylene, acrylic multipolymer, polypropylene, ionomer, and other compounds.

Milk: The success or failure of plastics in milk packaging will influence future volume consumption of resins for bottles in a significant way. In 1966, milk packaging was a 26.5 billion unit outlet for all containers; of this, plastics held 74 million units or less than three-tenths of 1 percent. By 1976, plastic will probably have captured about 20 percent of the total unit requirements in milk packaging, mostly in 1 gallon and half gallon containers. In addition, returnable plastic containers are likely to satisfy a substantial percentage of the remaining 5 billion milk fillings now going to glass annually.

This forecast is made on the basis that technological advances will solve the container filling problem soon. We also expect that special marketing strategies will be used by bottle makers to make change-over for dairies financially attractive.

High density polyethylene will most likely be the resin used for milk containers. If a significant market for returnable plastic milk containers develops, it is likely that polypropylene would also find a place in milk packaging.

Toiletries and Cosmetics: The use of plastics for toiletries and cosmetics is already well established. In the 1966 to 1976 period, plastics units used in this application category should quadruple (from 769 million to—3.4 billion units). PVC bottles are expected to become much more important in toiletries, although high density polyethylene and other resins are likely to be used in substantial volume also. The products most likely to be packaged in plastics are hair oils, shampoos, creams, and rinses.

The net result of our analysis indicates that plastic bottles will be one of the more common sights on retail shelves in 1976. Both the number of units sold and the weight of plastics consumed will be more than five times greater than comparable 1966 figures. Consumer acceptance of plastic bottles is well established, especially in nonfood items, and the increasing sophistication of resin technology will enable packaging producers to custom-design packages for each product. In addition, many producers will have the capability to design, install, and service molding equipment and filling equipment used with their resins.

Our forecasts do not include more than negligible plastics use in beer and soft drink containers. Recently, there has been considerable excitement over the fact that certain (unnamed) plastics are being test marketed for both beer and soft drinks. To compete successfully against glass and metal, plastics have to perform a number of functions—hold pressure, not affect taste in any way, accept decoration readily, handle rapidly, stack well, etc. Plastics can meet these requirements today, but not at a cost competitive with metals and glass. Present plastics technology has not advanced far enough to make plastic a threat to traditional materials.

It has been noted in other sections of this report that metal and glass technologies are advancing significantly. Very rapid advances in technology and machinery capabilities would be required to make plastics attractive on the broad scale basis that glass and metal containers now enjoy. Resin costs would also have to decline further. However, it should also be noted that beer and soft drink companies are innovative packagers; should consumer reaction favor plastics, even at a premium price, rapid technological development is possible. Our evidence indicates, however, that steel, aluminum, and glass will be the materials used for beer and soft drink packages in the next decade.

Plastic Closures

In 1966, 10.4 billion plastic closures were used for all types of containers. Of these, 5.5 billion were for glass; 2.7 billion for plastic; 1.0 billion for metal containers; and 1.2 billion for metal tubes. An estimated 85 million pounds of various resins were used for closures in 1966, including such items as plastic gaskets and cap liners. Of these, 34 percent were thermoset compounds (urea and phenolics); and the balance, thermoplastics, such as polyethylene, polypropylene, polystyrene, and vinyls.

Closures are made by injection molding, and there are relatively few configuration limitations in making them compare with metals. Special dispensing caps, safety caps, and other special styles are likely to continue to proliferate and show rapid growth. In addition, the rapid growth of plastic bottles almost assures a similar growth of plastic closures.

We have forecast a total plastic consumption of 210 million pounds for closures in 1976. The thermoplastics will take an increasingly larger share and will most likely represent around 80 percent of the total in 1976; the thermosets will thus decline to about 20 percent of total plastic closures. Although the great bulk of resin volume will go into caps for glass, metal, and plastic containers, about 10 percent of the resin by weight will end up in cap liners and jar lids made of vinyls. The vinyl cap liners and jar lids are rapidly displacing cork and rubber and will continue to do so for the next few years. The outlook for plastic closures, then, is not unlike that for other plastic packaging configurations—very favorable.

Plastic Tubes

Plastic tubes consumed an estimated 15 million pounds of resin in 1966, compared with 3 million pounds in 1963. In 1967, an estimated 20 million pounds were used for tubes, accounting for 18 percent of the total unit volume in tubes. Therefore, during recent years, plastics have taken away much of the potential growth of metals, such as aluminum, used for tubes.

Low density polyethylene accounts for over 80 percent of the resin consumption, but more expensive resins such as polypropylene and ionomer are used because they offer better clarity and product protection.

Plastic tubes are presently being used primarily in toiletries and cosmetics (shampoo, hair creams). However, the volume market in tubes is now in dentifrices and potentially in pharmaceuticals.

The outlook for plastics in tubes is for continued growth. Plastics will appear both as the single material of which tubes are made and also as components of composite tubes. Composites are now beginning to appear. One material combination already in service is a four-layer composite toothpaste tube (Vote) for polyethylene/paper/foil/polyethylene. The tube is lower in cost than either metals or plastics. It protects the product and is tough and highly printable. Thus, for certain products, at least, it appears to fulfill the competitive criteria necessary to make it a significant breakthrough in this type of container.

We have forecast a total consumption of 40 million pounds of plastics in tubes in 1976 (or about 450 million units). This is a growth rate of about 10 percent per year. Both metals and composites (using plastics) are expected to be competitive with plastics on a cost and performance basis, and the most probable outlook is that none of these will have a dominant position in collapsible tubes. Low density polyethylene resin compounds should account for the greatest volume in plastic tubes, although the other types of plastics such as polypropylene and ionomer are likely to be used in increasing volumes.

WOOD

Wood is a traditional packaging material but represents only a minor segment of all packaging materials today. In 1965 wood products accounted for 4.2 percent ($638 million) of all dollar shipments of packaging materials and 8.6 percent (7.9 billion pounds) of the total weight of all packaging materials.

Most wood containers are used for agricultural and industrial packaging—fruits, vegetables, and poultry; and plumbing, castings, auto parts, machinery, chemicals, and so forth. A few wood containers are used in consumer packaging—cigar boxes, berry boxes, holiday gift boxes, and the like.

Wood containers are used primarily because of their relatively low cost and high strength. They often go through several cycles of use before they are discarded. For example, the boxes in which fruit and vegetables are shipped from one part of the country to another may be resold at the destination to local truck farmers who will use them for their produce.

Wood is usually used in its natural state—it is seldom coated or chemically altered, and it is not likely that wood containers will be modified in such ways in the future.

There are four basic types of wooden containers: (1) nailed wooden boxes, (2) wirebound boxes, (3) slack and tight cooperage (barrels), and (4) wood veneer. Table 54 and Figure 24 summarize our forecast in each of these categories. Table 55 presents the same data in detail.

Nailed Wooden Boxes

Most of the wood which ends up in packaging is used in nailed wooden boxes. In 1966 nailed wooden boxes accounted for consumption of 6.6 billion pounds of wood.

TABLE 54.—*Consumption of wood in packaging by end use: 1966 and 1976*

End use	Quantity (in millions of pounds)		10-year rate of change (percent)
	Actual—1966	Forecast—1976	
Nailed wooden boxes	6, 560	7, 320	1. 1
Wirebound boxes	1, 260	1, 260	0
Slack cooperage	56	25	−7. 7
Tight cooperage	176	205	1. 5
Veneer packages	66	35	−6. 2
Total	8, 118	8, 845	. 9

Source: Midwest Research Institute.

These containers come in many sizes and strengths as indicated by the variety of purposes for which they are commonly used: fruits and vegetables, cigar boxes, secondary containers for milk and beverage products, and industrial products.

Military requirements have given rise to new packaging techniques involving wooden boxes. Recently, wood boxes have been combined with internal cushionings of molded polystyrene foam.

There is a trend toward larger size, semi-bulk containers. These containers will probably make more use of plywood than of solid board; although where rough handling is expected or heavy protection is needed, solid board will still be used.

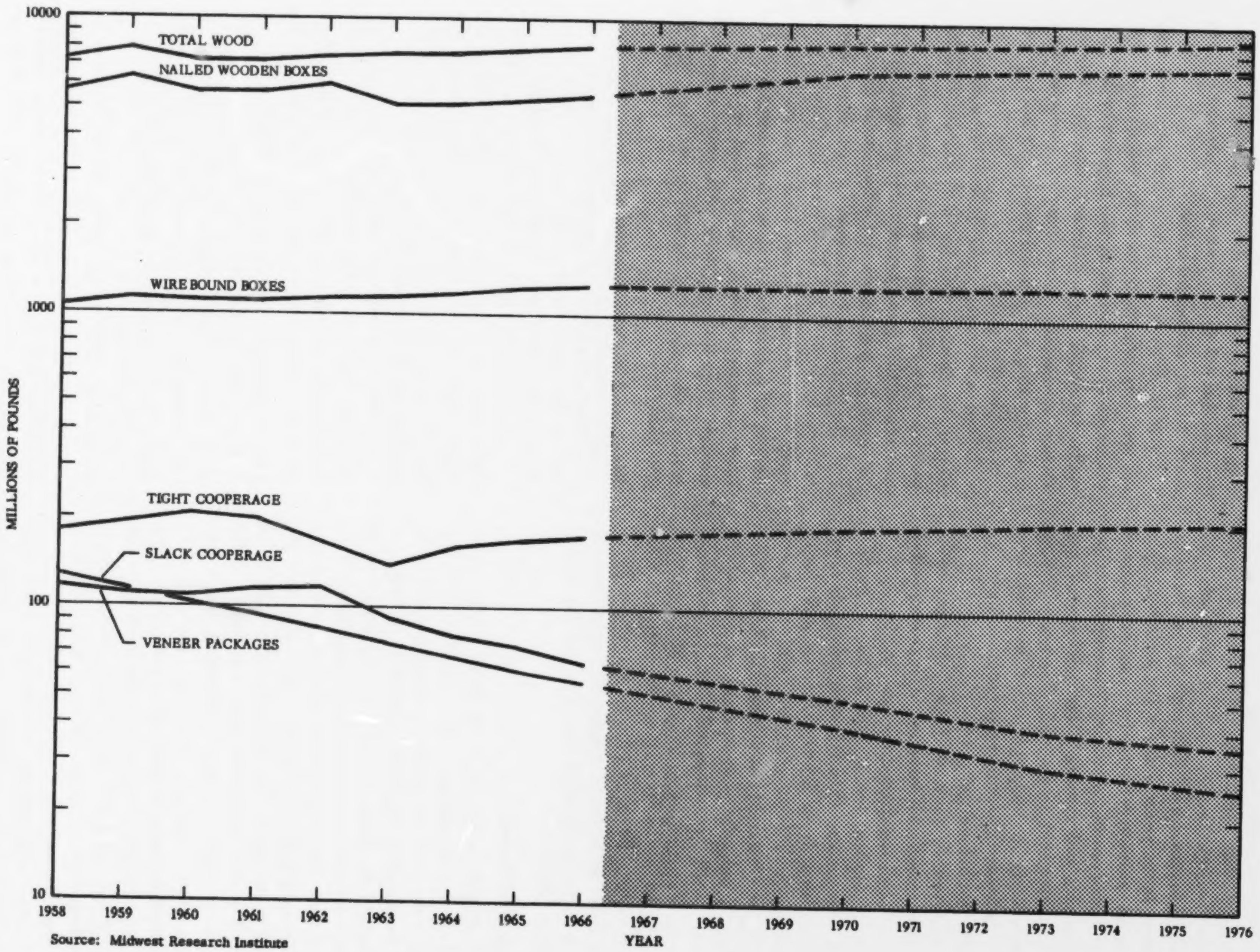
New assembly techniques have been developed which utilize metal braces instead of nails. The container is shipped unassembled to the packager who assembles it in his plant.

Plastic is the chief source of competition for nailed wooden boxes. Wooden cigar boxes are being replaced with plastic boxes. Polystyrene beverage cases are being substituted for the far heavier wooden cases, as is true with certain agricultural field "tote boxes." However, there is not yet a substantial movement away from wood boxes to plastics because wood boxes have a long life and plastics are relatively expensive. For instance, it would be quite costly for a beverage distributor to replace his wooden beverage carriers with plastic carriers all at once.

TABLE 55.—*Shipments of wooden containers by type: 1958–1976*

Type of container	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976
Nailed wooden boxes (millions of board feet)	3, 350	3, 700	3, 330	3, 330	3, 500	3, 610	3, 610	3, 710	3, 848	4, 030	4, 165	4, 305
Wirebound boxes (1,000 units)	179, 677	188, 000	185, 000	186, 600	191, 080	190, 125	196, 000	207, 000	210, 200	215, 000	220, 000	230, 000
Tight cooperage (1,000 units)	2, 240	2, 400	2, 544	2, 442	2, 205	1, 859	2, 156	2, 260	2, 340	2, 530	2, 670	2, 730
Veneer packages (millions of square feet)	1, 125	1, 045	1, 025	1, 100	1, 089	882	767	650	570	435	350	300

Source: *Modern Packaging Encyclopedia.* William C. Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p. *Ibid.*, Vol. 39, No. 4A, December 1965. 863 p. *Ibid.*, Vol. 38, No. 3A, November 1964. 833 p.



Source: Midwest Research Institute

FIGURE 24.—Consumption of wood in packaging: 1958–1976 (millions of pounds)

In some military packaging applications, polystyrene molded foam has entirely replaced wooden boxes. The foam has high shock absorbing capabilities, precision molding tolerances, a high strength-to-weight ratio, and is relatively inexpensive to produce. Although it is initially expensive, polystyrene foam offers a considerable savings in shipping costs because of reduced weight. For example, if a wood package weighs 29 pounds, a polystyrene foam package of the same capacity will weigh only 3 pounds. Foam is quite likely to displace wood in situations where individually packaged items must be carefully protected.

In addition to plastics, nailed wooden boxes have felt some competition from corrugated containers and wirebound boxes.

Nailed wooden boxes will have a modest growth rate in the 1966 to 1976 period because of competition from other materials and forms of packaging. The competition will be partly offset by new assembly techniques, lighter weight containers, and the development of a few new markets, such as shipping heavy industrial products. Future growth at a rate of 1.1 percent a year is likely; consumption will increase from 3.8 billion board feet in 1966 to 4.3 billion board feet in 1976. In terms of weight, this is an increase from 6.6 billion pounds in 1966 to 7.3 billion pounds in 1976.

Wirebound Boxes

Wirebound boxes are made from lumber, plywood, or veneer, and are bound together by heavy gauge wire held in place by steel staples. The steel wire makes the boxes extremely strong.

There is currently a trend toward larger wirebound boxes for use in semi-bulk packaging. This means that the average size of wirebound boxes will increase and more product will be carried per unit. For example, one company has designed a 200 cubic foot container that can hold 10,000 pounds of metal castings. Wirebound pallet containers that facilitate handling, stacking, and shipping have been developed for industrial items.

Wirebound boxes are also being used more frequently for products that have been shipped unpackaged in the past—heavy duty machinery and large parts.

In some applications, wirebound boxes have been displaced by materials such as corrugated and solid fiber. For example, the development of hot-melt coatings has enabled the wet strength of corrugated to be greatly increased. Coated corrugated is now used for shipping ice-packed poultry and has taken away about 30 percent of that market from wirebound boxes.

Even in cases where wirebound wooden boxes are not completely displaced by some other type of container, the wood in the boxes may be partially displaced by a different material. For instance, a wirebound box may be replaced by a container that has a wood frame and sides, paper lining, and corrugated ends.

In terms of total wood utilized in wirebound boxes, the demand will be fairly stable. The displacement of some of the wood by other materials and the loss of some agricultural markets will be balanced by new markets for industrial products and the continued development of larger containers. In 1966, 1.3 billion pounds of wood were used in wirebound boxes, based on an average weight of 6 pounds per box. Approximately the same amount of wood will be used in 1976, although the tonnage will represent a greater number of larger and lighter boxes than are in use today.

Slack and Tight Cooperage

Cooperage includes all types of wooden barrels and casks, either liquid-tight or not. The hoops around the barrel may be of metal or wood.

Liquid-tight barrels are usually made of white oak, red oak, gum, ash, or Douglas fir. They range in size from 20 to 60 gallons. The barrels are used almost exclusively for aging whiskey prior to bottling and sale.

The use of barrels for aging whiskey is a longstanding tradition and is unlikely to change in the next decade. At the same time, there are no indications that liquid-tight cooperage will be used for any other purpose in significant volume.

In recent years the total number of liquid-tight barrels has fluctuated between 2.1 million and 2.8 million units a year. The fluctuating demand is tied directly to the annual production of unaged whiskey.

Between 1966 and 1976, barrel production should rise from 2.34 to 2.73 million units. This increase represents a 1.5 percent annual growth rate which will result in a product weight increase from 176 million pounds to 205 million pounds in the 1966–1976 period.

Slack cooperage has been used to ship non-liquid products such as powdered milk and eggs, chemicals, sugar, salt, nails, glass and pottery, soaps, and various foods—meats, poultry, potatoes, apples, fish, and vegetables. The barrels may be either unlined or lined with a substance such as glue, paraffin, paper, or plastic film.

The cooperage industry is based on a long tradition of craftsmanship and small local plants. The industry has been unable to meet the changing demand presented by new merchandising and packaging needs. As a result, competing containers such as steel drums, corrugated boxes, and unitized package forms have taken away most of the markets formerly held by slack cooperage.

Because slack cooperage can compete for only a limited number of applications, it is apparent that there will be further declines. The decline will be at the fairly rapid pace of 7.7 percent a year, from an estimated 56 million pounds in 1966 to 25 million pounds in 1976.

Wood Veneer

This category includes wood veneer and plywood containers, such as pails, drums, tubs, fruit and vegetable baskets, berry cups, and other wood veneer forms. These containers are used primarily for food products. The square footage of wood used for this type of package has declined substantially in the last few years. In 1966 it was nearly 50 percent lower than in 1962 (down 1.1 billion square feet to 570 million square feet). This veneer category excludes plywood and veneer included in the nailed wooden box and wirebound box categories.

The small veneer package is rapidly giving way to substitute materials and more efficient configurations. Although the bushel basket and the small berry basket still have a small share of the market, plastic containers, plastic film, paper, and paperboard will continue to displace them. Weight of all such containers will have declined from 66 million pounds in 1966 to 25 million pounds in 1976.

TEXTILES

The use of textiles as a packaging material has declined significantly in the past few years. In 1958, 918 million yards of textiles were used for packaging; in 1966 the amount used had dropped to 804 million yards. The decline would have been even greater if sandbags for Vietnam had been excluded from these figures.*

Most textile bags used for packaging are made from either burlap or cotton; only a small amount of synthetic fibers is used. The use of cotton has declined while burlap has increased its share of the textile market. In 1958 cotton accounted for 40 percent of the market and burlap for 58 percent; by 1963, cotton accounted for only 35 percent of the market, and burlap had grown to 64 percent.

Burlap bags are strong and have good tear and snag resistance characteristics. They are used for products that need minimal protection—feeds, seeds, fertilizers, potatoes, and the like—and that can withstand rough handling during distribution.

Cotton sacks have a tighter weave than burlap bags, and are usually used for products that might sift through the looser weave of burlap. Flour and rice are examples of products that are carried in cotton sacks.

Textile bags are often collected, renovated, and reused. Burlap bags may be reused commercially 10 or 12 times before disposal. Cotton sacks are usually put to a secondary use such as yard goods for items like dish towels.

Textile bags are receiving a great deal of competition from throw-away bags—multi-wall paper bags, plastic-lined paper bags, and plastic bags. In general, the throw-away bags are displacing the textile bags because they cost less, are strong, and provide a vapor barrier. Semi-bulk containers such as pallet bins are also competing with textile bags for high-volume customers. Sandbags are being displaced by woven polypropylene plastic bags, which do not rot as rapidly as burlap, are resistant to chemicals, and are lighter and stronger than burlap. It is likely that polypropylene bags will displace textile bags in other uses, and some textile manufacturers are even adapting their machinery to weave polypropylene.

Products that are traditionally packaged in textile bags are moving in two directions, both of which tend to reduce the use of textile bags: first, many products are being packaged in smaller consumer or "unit-of-use" sizes which favor plastic or paper packages. For example, 5 pounds of potatoes in a plastic bag rather than 50 pounds of potatoes in a burlap bag. Second, in commercial, non-consumer uses, extremely large bulk packaging and shipment are becoming more attractive. For example, flour may now be shipped in a railroad tank car to a large commercial bakery. Formerly, the same company may have received its flour in 100-pound cloth sacks.

---

*Sandbags accounted for 9.9 percent of total shipments of packaging textiles in 1966, compared with 5.7 percent in 1965 and 0.5 percent in 1964.

In spite of the loss of some of the market to other materials, textile bags, especially the very functional 50- and 100-pound sizes for feed, seed, and some foods, will still be used in substantial quantities for some time in the future. However, it is unlikely that any new high volume markets for textile bags will develop to offset the loss of traditional markets, nor are there any recent technological developments that could lead to new packaging applications for textile bags. The competing materials are simply more suited to modern distribution technology, are better packages, and are less expensive than textile bags.

We forecast a decline of about 5 percent a year in the use of textiles—from 804 million yards in 1966 to 480 million yards in 1976. In terms of millions of pounds of material used, this will be 300 million pounds in 1976 compared to 503 million pounds in 1966. This decline is consistent with the general trend away from reusable packaging materials. The forecast does not include bags that may be produced and exported for military uses. Table 56 presents an historical picture of bag production in linear yards; Table 57 depicts textile bag end-use distribution in percentage for the years 1958 through 1966.

TABLE 56.—*Shipments of textiles for packaging: 1958–1976*

In millions of linear yards

Year	Total shipments
1958	918
1959	945
1960	881
1961	847
1962	870
1963	860
1964	805
1965	740
1966	804
1970	655
1973	560
1976	480

Source: *Modern Packaging Encyclopedia.* William C. Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p. Forecasts by Midwest Research Institute.

MISCELLANEOUS PACKAGING MATERIALS

This section is reserved for the discussion of those packaging materials that are not strictly containers but are better classified as package components of various kinds. Items included here are (1) pallets and skids, (2) cushioning materials, (3) connective components such as tapes and twine, and (4) coatings or applied materials. Some package components are treated elsewhere, among them metal strapping, crowns and closures, plastic cushioning foams, molded paper used for cushioning, and corrugated dunnage. These latter items appeared better suited for inclusion under the base material discussion either because they are made of a single material, because it was

TABLE 57.—*Shipments of textile bags by end use: 1958–1966*

Percent of shipment in yards

End use	1958	1959	1960	1961	1962	1963	1964	1965	1966
Feed	38.1	29.2	33.6	31.3	30.0	27.4	25.9	23.3	22.8
Potatoes	12.3	10.9	12.6	12.3	12.1	12.4	13.9	15.4	15.0
Flour	16.4	20.7	16.7	18.7	16.0	14.0	14.9	11.1	10.9
Meal	5.5	5.3	6.5	7.0	5.5	6.7	6.0	6.4	3.6
Fertilizer	4.2	3.1	3.8	3.6	3.9	5.3	5.7	5.2	6.4
Seeds	5.8	6.7	5.9	6.0	5.9	6.4	6.0	5.8	5.3
Rice	3.7	4.7	5.0	3.4	5.4	5.2	5.7	6.4	4.8
Beans, peas	2.2	2.9	2.8	2.9	3.1	3.7	4.4	3.5	4.3
Other (including sandbags)	11.8	16.5	13.1	14.8	18.1	18.9	17.5	22.9	26.9
Total textile bags	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging,* 20(2):4, July 1967.

difficult to separate quantities in a meaningful manner, or because the technological discussion was pertinent to such components and would have had to be repeated if these components were treated in a separate section.

In 1966, 11.5 billion pounds of miscellaneous packaging materials were used. By 1976, the volume should have risen to 17.1 billion pounds, registering a growth rate in excess of 4 percent annually in the period. Table 58 summarizes our forecasts. Table 59 presents the same information in considerably more detail.

Table 58.—*Consumption of cushioning and component material by type: 1966 and 1976*

	Quantity (in millions of pounds)		Ten-year rate of change (percent)
	Actual—1966	Forecast—1976	
Pallets and skids	8,200	12,300	4.1
Shredded paper for packing	49	50	0.2
Excelsior and excelsior products	78	70	−1.1
Tag stock	375	540	3.7
Tapes	730	1,100	4.2
Cordage and twine	190	170	−1.1
Adhesives	600	930	4.5
Wax	577	900	4.5
Plastic coatings, polyethylene	320	440	3.2
Other plastic coatings	154	300	6.9
Inks	208	320	4.4
Total	11,481	17,120	4.1

Source: Midwest Research Institute.

Pallets and Skids

Distribution technology has contributed to the rapid growth in the use of pallets and skids. Many types of unfilled packages are palletized for shipment to the filling point, among them empty soft drink and beer containers. In addition, palletizing of boxes, sacks, cases, barrels, etc., has also taken on added importance in recent years. Pallets and skids have made their appearance as an integral part of a package when they are attached to bins or boxes.

Palletizing is used for carrying products from the factory, transporting them to the warehouse, and then to the point of use or sale. These units can be handled, moved, stacked, and transported efficiently. In addition, increasing attention is being given to package handling equipment and systems, including automatic depalletizing, pallet loading and automated storage and stacking. The emphasis is on "systems" which move a product efficiently from factory to end user.

Most pallets and skids are made from low grade lumber; however, metal, metal-reinforced wood, and corrugated units are also in use today. A typical wood pallet of 4 feet by 4 feet weighs about 150 pounds. Thus, pallets and skids are among the heaviest individual units used for packaging service. They have a long service life, but recycling is a function of cost more than of useful physical life. For example, a unit which cannot be economically returned to its source will be disposed of or sold for local use.

The "systems" concept in distribution will become a much more important factor in the next ten years, spurring the use of pallets and skids. These package components should grow at a rate of 4.1 percent annually in the period, with quantities increasing from 8.3 billion pounds in 1966 to 12.3 billion pounds in 1976. Most of this tonnage will continue to be wood, although paperboard constructions are beginning to make an appearance in volume.

Cushioning Materials

A number of the packaging materials previously discussed are used for cushioning, among them are plastic foams, corrugated paperboard, cellulose wadding, and honeycomb kraft paper. Only two types of materials were singled out for treatment here—shredded paper and excelsior. In contrast with other cushioning materials, these are used exclusively in interior packaging.

Shredded Paper for Packing

Shredded paper used to be a familiar packing especially for breakables like dishes, glass, lamps, and other products. However, it has not been used in significant quantity for many years now. Census data indicate that total consumption in 1963 was about 49 million pounds.

Shredded paper is difficult to handle, leaves fine particles on the product, absorbs and holds moisture, has poor fungus resistance, can have a corrosive effect, and makes unpacking and disposal a "messy" process. It is, of course, a very low cost material and exhibits excellent

TABLE 59.—*Consumption of miscellaneous packaging materials: 1958–1976*

In millions of pounds

Type of material	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976
Cushioning Materials:												
Shredded paper for packing	48	49	49	48	48	49	48	49	49	50	50	50
Excelsior and excelsior products	84	84	83	82	81	80	80	79	78	70	70	70
Total	132	133	132	130	129	129	128	128	127	120	120	120
Component materials:												
Tag stock	263	266	272	289	286	285	297	366	375	430	490	540
Tapes, gummed and pressure sensitive (except plastic and cloth backed)	371	410	450	500	550	597	650	700	730	870	990	1,100
Cordage and twine (selected categories)	198	197	196	195	194	193	192	191	190	180	170	170
Total	832	873	918	984	1,030	1,075	1,139	1,257	1,295	1,480	1,650	1,810
Coatings and other applied materials:												
Adhesives	430	450	460	475	500	520	550	580	600	720	820	930
Wax	820	830	826	834	716	583	580	568	577	630	750	900
Plastics, polyethylene	38	45	53	86	153	209	255	300	320	380	410	440
Other plastics	(a)	(a)	(a)	(a)	30	50	75	135	154	210	260	300
Inks (selected categories)	122	130	140	150	160	171	183	196	208	250	280	320
Total	1,410	1,455	1,479	1,545	1,559	1,533	1,643	1,779	1,859	2,190	2,520	2,890
Total pallets and skids (primarily wood)	2,283	2,714	3,227	3,837	4,562	5,434	6,363	7,447	8,200	10,300	11,200	12,300
Total (excluding pallets and skids)	2,374	2,461	2,529	2,659	2,718	2,737	2,910	3,164	3,281	3,790	4,290	4,820
Total miscellaneous	4,657	5,175	5,756	6,496	7,280	8,171	9,273	10,611	11,481	14,090	15,490	17,120

[a] Not available. Compiled by Midwest Research Institute.

shock absorption qualities for product protection. It has simply lost out to other forms of internal packing which do not exhibit the drawbacks of shredded paper. A variety of pads, honeycomb papers, corrugated board, plastic foams, and other special low cost constructions has made shredded paper essentially obsolete. There is, of course, some residual demand for the product and on this basis we carry this category in the forecast at a nominal 50 million pounds in 1976.

Excelsior

Data on excelsior are very limited. It is known, however, that excelsior is being displaced as a packaging material by other products. It has the same limitations as shredded paper—it is difficult to handle, "dusts," absorbs moisture, is affected by fungus, etc. Excelsior, of course, is a very low cost material and exhibits excellent shock absorption qualities. In packaging, it can be used in both bulk form and as the interior stuffing for protective pads. Our estimates are that about 78 million pounds were used in packaging in 1966; we expect 1976 production to have dipped to 70 million pounds.

Connective Component Materials

Tag Stock

This paper falls within the "special industrial papers" category of paper. It is a relatively heavy grade material (similar to office file folders) and is used primarily for tags. It is thus a peripheral packaging material. Tags are usually attached directly to a package item—stapled to a box or attached in some other manner to an unpackaged product. Tags are of course usually printed. End-use data were not available for this material.

Production of tag stock was 375 million pounds in 1966. The growth rate for the 1958 to 1966 period was 4.5 percent per year. However, much of this was accounted for by a one-year growth of 23 percent in 1965. In 1976, we have forecast production of 540 million pounds based on a growth rate of 3.7 percent per year.

Tapes

Tapes (gummed and pressure sensitive) are used extensively in packaging for a variety of applications—box, carton, and bag sealing and bundling: for "stapling" a product to a card; for carrying handles on cartons; and a variety of other applications including mail packaging. Tape manufactures have developed a number of tape types in the last few years; and there is also a wide variety of manual, semiautomatic, and automatic equipment to dispense and apply tapes.

Pressure sensitive tapes in particular have become quite sophisticated in recent years as adhesive technology has advanced. Pressure sensitive tapes may use a paper backing or be the film type (cellophane, acetate, vinyl, polyester, and glass reinforced). Standard gummed tapes usually are kraft paper backed with a simple water activated animal or vegetable glue.

Tape manufacturers have applied their advancing technology effectively and the use of tapes in packaging is growing rapidly, competing with stapling, steel strapping, and conventional carton sealing as well as with shrink wrapping.

In the 1958- to 1963-period, the growth rate of gummed pressure sensitive tapes was about 10 percent a year. We estimate that 730 million pounds of tape material were used in 1966. Tape use should generally parallel the growth of packaging as a whole, and we foresee an annual growth rate of 4.2 percent per year to 1976, resulting in consumption of 1.1 billion pounds in 1976.

Cordage and Twine

Selected types of cordage and twine were included as packaging components, primarily the hard fiber twines and the soft fiber cordage and twine. Rope, cable, fishing line, and some miscellaneous categories were omitted. Cordage and twine are made primarily of jute, paper and cotton, or manmade fibers such as nylon. They are, of course, used for a variety of applications from wrapping packages for mailing to baling of agricultural products. A number of automatic tying and wrapping machines are available, but in general cordage and twine are associated with agricultural uses, and simple hand and semiautomatic tying applications.

The quantity of cordage and twine declined from 198 million pounds to 193 million pounds in the 1958 to 1963 period. The soft fiber types (primarily paper, cotton, and artificial fiber) increased by 25 million pounds (from 80 to 105 million pounds), but hard fiber twines declined by 30 million pounds. Hard fiber twine declined from 59 percent of the total in 1958 to 45 percent in 1963. We have estimated cordage and twine consumption at 170 million pounds in 1976 representing a decline of 1.1 percent per year for the ten-year period.

Coatings and Other Applied Materials

The materials grouped in this category are used in a variety of ways on a variety of package types. Included here are adhesives, wax, plastic coatings, and inks. These materials are used primarily on paper and plastic, but they may be applied to any packaging materials—certain types of cans, for instance, are now seamed with adhesives.

Since these materials are applied as coatings, they may alter the performance characteristics or appearance of particular package configurations. However, their effect on the package from a disposal standpoint is often minor, and in terms of analytic criteria used, the significant implication of these materials is that they may discourage salvage; plastic coated papers, for instance, are virtually unusable with present repulping techniques; inks and adhesives are more readily processed.

Adhesives

A variety of adhesives is used in packaging, ranging from common vegetable adhesives to resins. Most of the adhesive consumption goes into paper and paperboard packaging—for construction of corrugated board, bag making, carton sealing, etc. Adhesives are also used widely for applying labels and laminating films and foils. There is a constant demand for new adhesives, particularly in flexible packaging, where new materials and materials combinations are used.

The trends in technology are toward adhesives that (1) achieve bonds by heat or by chemical reaction and dry instantly; (2) form barriers to gases and water; and (3) form stronger bonds with less material. The outlook is for a steady growth in consumption and continued development of new types of adhesives in the next decade, not only for paperboard and flexible packaging applications, but also for metal can seams, labels of all types, and a multitude of other sealing uses.

About 600 million pounds of adhesives (solids basis) were used in packaging in 1966. The use of adhesives will grow somewhat more rapidly than packaging materials as a whole, primarily because containerboard will enjoy high growth rates and because structured films, laminates, and other adhesive using materials will expand rapidly. A rate of 4.5 percent per year was used in our forecast, putting consumption at 930 million pounds per year in 1976.

Wax

Petroleum wax is used either as a coating or impregnation material for paper and paperboard. It is used as 100 percent paraffin wax, modified refined wax (90 percent wax, 10 percent modifiers) or as "hot-melt" blends in which the modifiers exceed 10 percent by weight. Wax and wax blends impart moisture resistance and heat seal properties, add gloss, and preserve the surface.

Petroleum wax has gone through a period of rapid change in recent years. Its traditional uses have been as a coating for milk cartons, wrapping papers, and paperboard containers. However, in 1961 polyethylene coatings began to displace wax for milk carton coating and by 1963 the volume of wax used for milk cartons had dropped by two-thirds. Since that time, new formulations using wax have been developed—in particular the hot-melt formulation for coatings and adhesives for paper, foil, films, and paperboard packages. In this new role, wax is a highly refined component ingredient. Meanwhile, the 100 percent paraffin coating is rapidly becoming a relic of the past.

From a volume standpoint, wax is now in a turn-around period. After a rapid decline, wax use in packaging should grow in the 1966 to 1976 period at a rate of about 4 percent or more. By 1976, a volume of 900 million pounds of wax in various forms is likely, up from 577 million pounds in 1966.

Polyethylene Coatings

Polyethylene made its most significant entry into packaging in 1961 when it was first used commercially on a widespread basis for coating paperboard milk carton blanks. As noted in the discussion of wax, it was accepted immediately and volume grew rapidly. Its entry was based on a rapidly developing extrusion coating technology, improved resin formulations, and a declining price trend which made it economical for use on high volume commodity type packages.

Polyethylene is used as a coating to alter the characteristics of the substrate. It imparts barrier properties to the substrate, particularly moisture resistance. Polyethylene is also used for its heat sealing properties, visual appeal (gloss, shine, clarity), and durability.

Virtually all polyethylene used for coatings in packaging is low density ployethylene applied by extrusion coating techniques. Paperboard accounted for about 58 percent of total polyethylene extrusion coatings or 179 million pounds in 1966 (Table 60). Other substrates—paper, film, and foil—are becoming more important.

The use of polyethylene coating resins expanded spectacularly from 1958 to 1965—from 38 million pounds to 300 million pounds. In 1966 it increased only another 20 million pounds, almost all of which was for coating paper, plastic films, and foil substrates. This sudden change in volume growth may be signaling a maturing market.

TABLE 60.—*Consumption of polyethylene extrusion coatings: 1962, 1964, and 1966*

In millions of pounds

Substrate	1962	1964	1966
Paper:			
Multiwall bags	12.5	12.0	20.7
Wraps, pouches, other	17.9	31.0	49.1
Total paper	30.4	43.0	69.8
Paperboard:			
Milk cartons	77.7	127.5	148.0
Other—dairy, bakery, frozen foods, cups, etc	8.8	26.7	31.2
Total paperboard	86.5	154.2	179.2
Films: Meats, cheese, boil-in bags, dried fruits, nonfood, and miscellaneous	21.8	36.9	37.9
Foil:			
Food	3.7	6.0	15.0
Nonfood	10.2	10.0	14.6
Total foil	13.9	16.0	29.6
Other:	0.8	5.2	3.5
Grand total	153.4	255.3	320.0

Source: *Modern Packaging Encyclopedia*. William C. Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p. *Ibid.*, Vol. 39, No. 4A, December 1965. 863 p. *Ibid.*, Vol. 38, No. 3A, November 1964. 833 p.

Plastic films and other plastics are competing for end uses served by polyethylene coated materials; thus, polyethylene as a coating competes against itself. Paperboard, the prime user of PE coatings, is no longer the growth market it was in recent years. For example, all-plastic milk bottles are beginning to be a factor in milk packaging, and with wax coatings virtually displaced, this is a mature market for polyethylene. Polyethylene also finds itself in competition with hot-melt waxes, polyvinylidine chloride (Saran), and coating materials for other types of paperboard packaging, e.g., frozen foods.

Coating technology is well established. While constant improvements are being made, the greatest advances in these techniques were probably made in the early 1960's. (Today the greatest advances in plastics technology are coming in film extrusion.) The resin formulations are also well developed.

On the basis of the above, we expect lower growth rates for PE coatings than were experienced in the early 1960's. Our volume forecast is based upon a declining percentage of polyethylene for coating paperboard but increasing use of paper, film, and foil. In 1976, the quantity of polyethylene coatings should reach 440 million pounds compared with 320 million pounds in 1966. This is a growth rate of 3.2 percent per year for the ten-year period.

Other Plastic Coatings

A variety of plastic coatings other than polyethylene is also used for coating paper, paperboard, film, foil, glass, and metal. These materials accounted for 154 million pounds, or one third, of total plastic coatings used for packaging. The types and quantities of each material used are shown in Table 61.

Although growth of the combined group has been impressive, only ethylene vinyl acetate and polyvinyl acetate have been increasing in volume in the last two years. Some materials, like cellulose nitrate and vinylidene chloride, are caught up in a declining substrate market (cellophane). Most of the rest are showing little change in volume from year to year.

We did not attempt to evaluate the "other plastic coating" resins in detail but have based our quantity forecast on a relatively rapid growth

TABLE 61.—*Plastic coatings consumed in packaging by type of plastic: 1965, 1966, and 1976*

In millions of pounds

Plastic type	1965	1966	1976
Polyethylene, low and high density, extruded	300	320	440
Ethylene-vinyl acetate	18	22	......
Vinyl chloride resin (for interior coatings of containers)	15	13	......
Alkyd, polyester, acrylic, epoxy, etc. (for exterior can coatings)	14	17	......
Other resins for interior coating of containers (phenolic, epoxy, butadiene, etc.)	6	7	......
Vinyl chloride resin on paper, film, and foil	4	4	......
Other vinyl chloride coatings (including on glass bottles)	3	3	......
Polyvinyl acetate (dry lb)	15	25	......
Cellulose nitrate, saran, vinyl chloride, etc., used for coating cellophane, etc	40	38	......
Miscellaneous (including polyvinyl alcohol, acrylics, low-molecular-weight PE, saran and PE emulsions, styrene-butadiene, etc.)	20	25	......
Other plastics, total	135	154	300
Total	435	474	740

Source: *Modern Plastics*, 45(5):93, Jan. 1968. Midwest Research Institute.

in the vinyl acetate formulations which are used in hot-melts and modest growth in the other types. Production of these plastics should reach 300 million pounds in 1976, up from 154 million pounds in 1966.

Inks

Inks are one of the important groups of materials used in packaging. Printing usually appears somewhere on nearly every package. It may be used simply to label the contents or to sell the product by multicolor printing.

A multitude of advances have been made in ink formulations and printing techniques in recent years. In general, developments have resulted in lower printing costs, improved color and resolution, higher printing speeds, and faster drying inks. There has been a noticeable increase in the quantity and quality of printing in recent years, particularly for consumer packaging. An example is the corrugated box which was once relegated to backroom storage but today very often appears on the sales floor and is color printed for attractive display.

Between 1958 and 1963 the quantity of inks reported as "container and label inks" in Bureau of Census reports increased at the rate of 7 percent per year—rising from 122 million pounds in 1958 to 171 million pounds in 1963. Letterpress is relatively less important today than in 1958; lithographic, offset, gravure, and flexographic processes are all becoming much more important for packaging. Another process which has had considerable promise but has not yet reached commerical success is electrostatic printing. In this technique, ink is deposited on the substrate surface by being drawn from a charged plate.

Package printing will continue to be an area of concentrated technological development. The continued development of improved inks and printing processes will be the key to more widespread printing applications in packaging. Because this is a highly active field, we have forecast a higher growth rate for inks than for packaging materials in general. Ink consumption for packaging and labels is estimated to reach 320 million pounds in 1976, up from 208 million pounds in 1966, a growth rate of 4.4 percent per year.

TABLE 62.—*Total packaging consumption by type of material: 1966–1976*

Packaging material description	Quantity In millions of pounds		Ten-year rate of change (percent)
	Actual—1966	Forecast—1976	
Paper and paperboard	50, 316	73, 850	3. 9
Metals	14, 304	16, 830	1. 6
Glass	16, 463	23, 800	3. 8
Plastics	2, 199	6, 260	11. 0
Wood	8, 118	8, 845	. 9
Textiles	503	300	−5. 0
Total	91, 903	129, 885	3. 5
Miscellaneous	11, 481	17, 120	4. 1
Grand total	103, 384	147, 005	3. 6

Source: Midwest Research Institute.

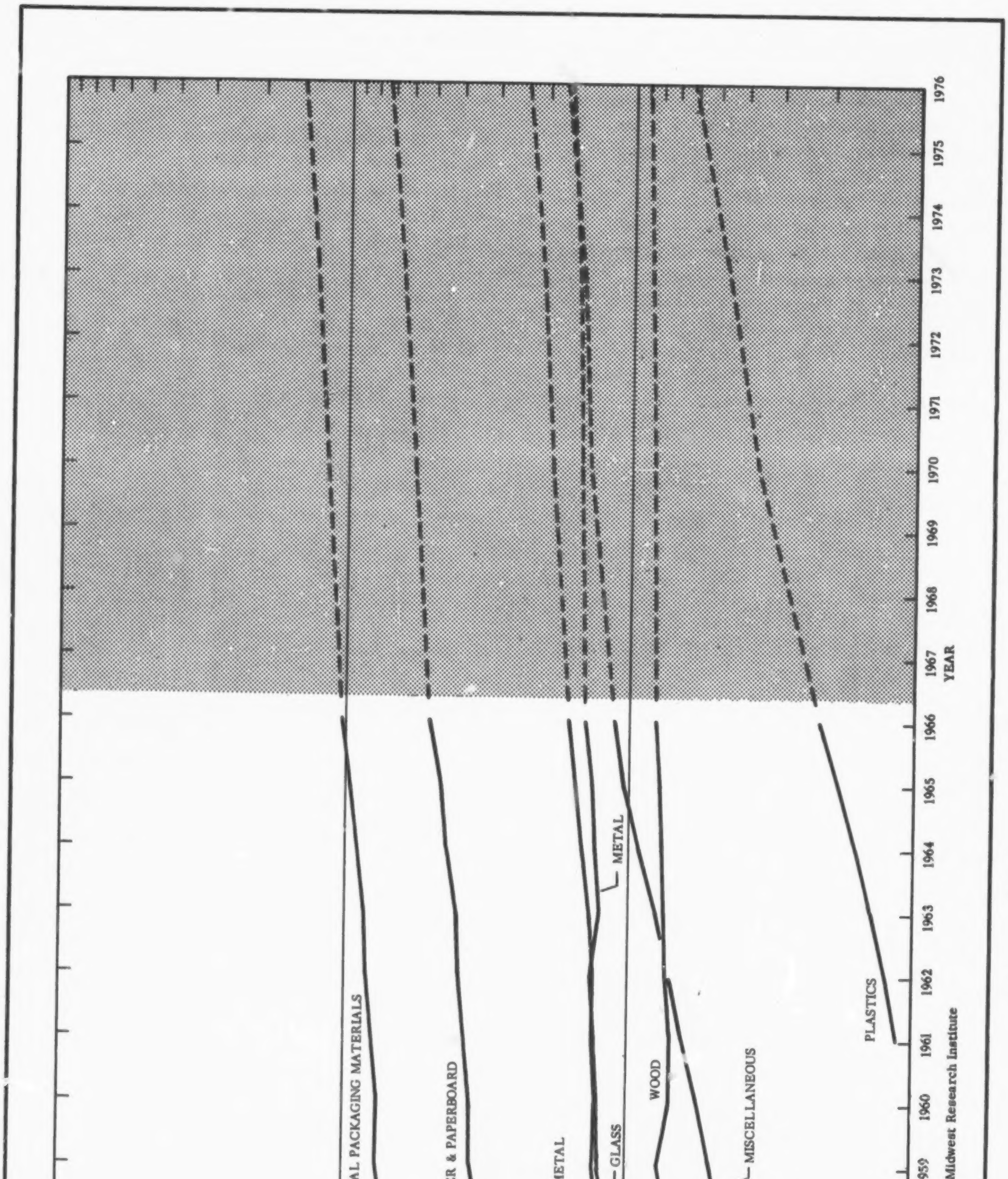
SUMMARY

Overall, packaging materials, on a tonnage basis, will increase at a rate of 3.6 percent annually in the 1966 to 1976 period. The quantity of all materials consumed will increase from 103.4 billion pounds in 1966 to 147.0 billion pounds ten years later. Table 62 and Figure 25 summarize the forecast for the years 1966 and 1976. Table 63 shows historical and forecast quantities, by major categories, for the period 1958 to 1976. Table 64 presents these data in detail.

The ranking of the major materials on the basis of the weight they contribute to solid waste will not change significantly in the forecast period. Paper, glass, metals, wood, plastics, and textiles—in that order—will be the major materials in both 1966 and 1976. However, the relative dominance of the materials will undergo changes. Paper, glass, and plastics will have a larger share of the tonnage produced; metals, wood, and textiles will decline in percent of total (Table 65).

Per capita use of packaging materials will increase from 525 pounds in 1966 to 661 pounds in 1976. Use of these materials, in 1958, stood at 404 pounds (Table 66, Figure 26).

The impact of packaging materials on solid waste in terms of disposability is taken up in Part II of this report which follows.



Source: Midwest Research Institute

FIGURE 25.—Consumption of packaging materials (billions of pounds)

TABLE 63.—*Consumption of packaging materials by type: 1958–1976*

In millions of pounds

Type of material	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976
Paper and paperboard	33, 103	36, 857	36, 677	38, 050	40, 398	41, 887	44, 079	46, 948	50, 316	58, 440	65, 640	73, 850
Metals	12, 589	13, 134	12, 870	13, 265	13, 688	12, 712	13, 226	13, 532	14, 304	15, 070	15, 880	16, 830
Glass	11, 866	12, 781	12, 888	13, 398	13, 383	13, 928	14, 752	15, 705	16, 463	19, 000	20, 900	23, 800
Plastics	736	864	983	1, 146	1, 282	1, 405	1, 610	1, 880	2, 199	3, 620	4, 695	6, 260
Wood	7, 199	7, 836	7, 190	7, 185	7, 461	7, 584	7, 622	7, 855	8, 118	8, 390	8, 610	8, 845
Textiles	574	591	551	529	544	538	503	463	503	410	350	300
Total	66, 067	72, 063	71, 159	73, 573	76, 756	78, 054	81, 792	86, 383	91, 903	104, 930	116, 075	129, 885
Miscellaneous	4, 657	5, 175	5, 756	6, 496	7, 280	8, 171	9, 273	10, 611	11, 481	14, 090	15, 490	17, 120
Grand total	70, 724	77, 238	76, 915	80, 069	84, 036	86, 225	91, 065	96, 994	103, 384	119, 020	131, 565	147, 005

Source: Midwest Research Institute.

TABLE 64.—*Consumption of packaging materials by type: 1958–1976*

In millions of pounds

Type of material	SIC number	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976
Paper and paperboard		33, 103	36, 857	36, 677	38, 050	40, 398	41, 887	44, 079	46, 948	50, 316	58, 440	65, 640	73, 850
Paperboard—total		24, 077	26, 957	26, 792	28, 006	29, 869	31, 084	32, 894	35, 207	38, 131	45, 160	51, 380	58, 500
Containerboard	26311	14, 519	16, 465	16, 374	17, 323	18, 593	19, 277	20, 684	22, 398	24, 915	30, 280	35, 060	40, 580
Folding boxboard	2631312	5, 380	5, 782	5, 846	5, 975	6, 241	6, 434	6, 591	6, 867	7, 229	8, 070	8, 770	9, 530
Special foodboard	2631211	2, 609	2, 889	2, 894	3, 046	3, 242	3, 346	3, 503	3, 673	3, 809	4, 610	5, 320	6, 140
Set-up boxboard	2631412	1, 077	1, 152	1, 050	994	1, 048	1, 054	1, 068	1, 095	1, 120	1, 050	1, 010	960
Tube, can, and drum stock	2631512–16	492	669	628	668	745	973	1, 048	1, 174	1, 058	1, 150	1, 220	1, 290
Flexible paper—total		7, 312	7, 941	7, 899	8, 018	8, 346	8, 482	8, 773	9, 219	9, 434	10, 240	10, 960	11, 780
Wrapping paper	2621601	1, 134	1, 192	1, 132	1, 090	1, 166	1, 144	1, 202	1, 218	1, 244	1, 350	1, 430	1, 520
Shipping sacks	2621614	1, 652	1, 740	1, 760	1, 780	1, 752	1, 902	1, 924	1, 948	1, 984	2, 080	2, 160	2, 240
Bag paper	2621618	2, 178	2, 316	2, 494	2, 558	2, 752	2, 752	2, 962	3, 248	3, 358	3, 910	4, 410	5, 000
Converting paper	2621620	2, 010	2, 341	2, 159	2, 222	2, 294	2, 296	2, 293	2, 403	2, 424	2, 440	2, 470	2, 500
Glassine, greaseproof, and vegetable paper	2621632	338	352	354	368	382	388	392	402	424	460	490	520
Specialty paper—total		1, 714	1, 959	1, 986	2, 026	2, 183	2, 321	2, 412	2, 522	2, 751	3, 040	3, 300	3, 570
Coated, printing and converting paper—coated one side		460	500	517	534	579	594	642	668	732	870	1, 000	1, 140
Book paper, uncoated—converting and miscellaneous	2621421–29	627	755	739	741	803	874	898	934	1, 066	1, 200	1, 310	1, 430
Tissue paper	2621878	440	492	480	469	471	472	462	475	472	440	420	400
Pulp, pressed and molded	2646231–98	187	212	250	282	330	381	410	445	481	530	570	600
Metal		12, 589	13, 134	12, 870	13, 265	13, 688	12, 712	13, 226	13, 532	14, 304	15, 070	15, 880	16, 830
Steel cans	3411002	9, 522	9, 898	9, 602	10, 028	10, 340	9, 154	9, 474	9, 734	10, 348	10, 600	10, 990	11, 420
Aluminum cans and ends	3411002	...	...	50	65	76	170	220	275	329	700	1, 000	1, 400
Collapsible metal tubes	34960	24	26	28	33	33	40	38	35	32	30	30	25
Rigid aluminum foil containers	3497033	36	48	54	57	66	72	80	85	88	110	130	150
Aluminum foil converted	3497031	157	185	174	190	202	218	238	251	266	350	400	465
Steel drums and pails	34911–13	1, 462	1, 546	1, 682	1, 620	1, 632	1, 636	1, 696	1, 612	1, 646	1, 610	1, 590	1, 560
Metal strapping	3498057	700	690	620	594	636	670	724	734	800	870	930	990
Gas cylinders	34434	128	152	112	108	124	116	108	128	120	120	120	120
Metal caps	34616	223	234	226	234	239	239	243	254	263	280	300	320
Metal crowns	34617	337	355	322	336	340	397	405	424	412	400	390	380

Glass	32210	11, 866	12, 781	12, 888	13, 398	13, 383	13, 928	14, 752	15, 705	16, 463	19, 000	20, 900	23, 800
Plastics		736	864	983	1, 146	1, 282	1, 405	1, 610	1, 880	2, 199	3, 620	4, 695	6, 260
Rigid and semi-rigid—total		106	127	207	318	408	456	584	727	882	1, 680	2, 345	3, 350
Bottles	30794	23	32	65	125	175	195	227	270	304	730	1, 150	1, 700
Tubes	30794					NA	3	3	10	15	30	35	40
Formed and molded	30794	61	73	120	140	175	213	288	375	478	800	1, 000	1, 400
Closures		22	22	22	53	58	65	66	72	85	120	160	210
Film—total		630	737	776	828	874	949	1, 026	1, 153	1, 317	1, 940	2, 350	2, 910
Cellophane	2643241	403	436	439	423	410	405	410	405	395	360	340	320
Polyethylene film	2643234	175	247	280	340	380	440	500	615	730	1, 280	1, 610	2, 030
Other plastic film	2643235	52	54	57	65	84	104	116	133	192	300	400	560
Wood		7, 199	7, 836	7, 190	7, 185	7, 461	7, 584	7, 622	7, 855	8, 118	8, 390	8, 610	8, 845
Nailed wooden boxes	2441	5, 695	6, 290	5, 661	5, 661	5, 950	6, 137	6, 137	6, 307	6, 560	6, 850	7, 080	7, 320
Wirebound boxes	24420	1, 078	1, 128	1, 110	1, 116	[illegible] 146	1, 140	1, 176	1, 242	1, 260	1, 260	1, 260	1, 260
Slack cooperage	2445012	127	114	103	[illegible]	[illegible]	75	68	61	56	40	30	25
Tight cooperage	2445953	180	194	207	[illegible]	[illegible]	139	160	170	176	190	200	205
Veneer packages	24430	119	110	109	116	[illegible]	93	81	75	66	50	40	35
Textile bags	23930	574	591	551	529	544	538	503	463	503	410	350	300
Miscellaneous		4, 657	5, 175	5, 756	6, 496	7, 280	8, 171	9, 273	10, 575	11, 481	14, 090	15, 490	17, 120
Cushioning materials:													
Shredded paper	2649568	132	133	132	130	129	129	128	128	127	120	120	120
Excelsior	2429081–92												
Component materials:													
Tag stock	2649582, 88	832	873	918	984	1, 030	1, 075	1, 139	1, 257	1, 295	1, 480	1, 650	1, 810
Tapes	26413–14												
Cordage and twine	2298												
Coatings and applied materials:													
Adhesives	28911	1, 410	1, 455	1, 479	1, 545	1, 559	1, 533	1, 643	1, 779	1, 859	2, 190	2, 520	2, 890
Wax	291151												
Plastics													
Inks	28930												
Pallets and skids	24992	2, 283	2, 714	3, 227	3, 837	4, 562	5, 434	6, 363	7, 447	8, 200	10, 300	11, 200	12, 300
Total—excluding miscellaneous		66, 067	72, 063	71, 159	73, 573	76, 756	78, 054	81, 792	86, 383	91, 903	104, 930	116, 075	129, 885
Grand total—all materials		70, 724	77, 238	76, 915	80, 069	84, 036	86, 225	91, 065	96, 958	103, 384	119, 020	131, 565	147, 005

Source: Midwest Research Institute.

TABLE 65.—*Consumption of packaging materials by kind: 1958–1976*[a]

In percent by weight

Type of material	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970	1973	1976
Paper and paperboard	50.1	51.2	51.5	51.7	52.6	53.7	53.9	54.3	54.3	55.7	56.6	56.9
Metals	19.0	18.2	18.1	18.0	17.8	16.3	16.2	15.7	15.6	14.4	13.7	13.0
Glass	18.0	17.7	18.1	18.2	17.5	17.8	18.0	18.2	17.9	18.1	18.0	18.3
Plastics	1.1	1.2	1.4	1.6	1.7	1.8	2.0	2.2	2.4	3.4	4.0	4.8
Wood	10.9	10.9	10.1	9.8	9.7	9.7	9.3	9.1	8.8	8.0	7.4	6.8
Textiles	.9	.8	.8	.7	.7	.7	.6	.5	.5	.4	.3	.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total weight (millions of pounds)	66,067	72,063	71,159	73,573	76,756	78,054	81,792	86,383	91,903	104,930	116,075	129,885

[a] Excludes miscellaneous categories. Source: Midwest Research Institute.

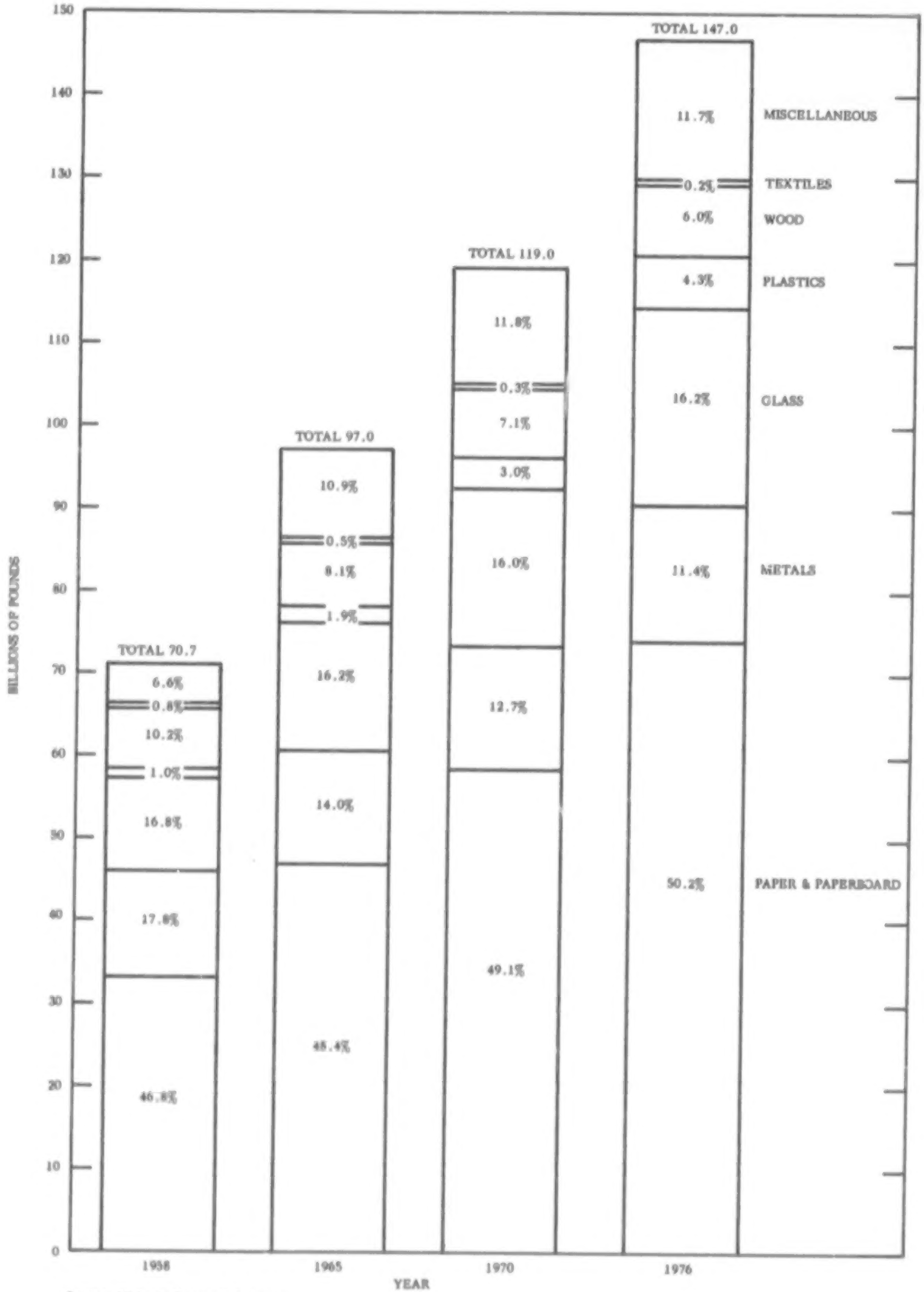
TABLE 66.—*Per capita consumption of packaging materials by kind: 1958–1976*

In pounds per capita

Type of material	1958	1959	1960	1961	1962	1963	1964	1965	1966	1970 [a]	1973 [a]	1976 [a]
Paper and paperboard	189. 3	207. 2	203. 0	207. 0	216. 4	228. 4	229. 4	241. 2	255. 5	283. 6	307. 0	332. 1
Metals	72. 0	73. 8	71. 2	72. 2	73. 3	69. 3	68. 8	69. 5	72. 6	73. 1	74. 3	75. 7
Glass	67. 8	71. 9	71. 3	72. 9	71. 7	75. 9	76. 8	80. 7	83. 6	92. 2	97. 8	107. 0
Plastics	4. 2	4. 9	5. 4	6. 2	6. 9	7. 7	8. 4	9. 7	11. 2	17. 6	22. 0	28. 2
Wood	41. 2	44. 1	39. 8	39. 1	40. 0	41. 3	39. 7	40. 4	41. 2	40. 7	40. 3	39. 8
Textiles	3. 3	3. 3	3. 0	2. 9	2. 9	2. 9	2. 6	2. 4	2. 6	2. 0	1. 6	1. 3
Total	377. 8	405. 2	393. 7	400. 3	411. 2	425. 5	425. 7	443. 9	466. 7	509. 2	543. 0	584. 1
Miscellaneous	26. 6	29. 1	31. 9	35. 3	39. 0	44. 6	48. 3	54. 3	58. 3	68. 4	72. 5	77. 0
Grand total	404. 4	434. 3	425. 6	435. 6	450. 2	470. 1	474. 0	498. 2	525. 0	577. 6	615. 5	661. 1

[a] Series C population projection used for 1970, 1973, and 1976.

Source: U.S. Department of Commerce, Bureau of the Census. *Current Population Reports*. Series P–25, No. 372 and No. 359. Washington, D.C., 1967. Midwest Research Institute.



Source: Midwest Research Institute.

FIGURE 26.—Consumption of packaging materials by weight: 1958–1976 (billions of pounds)

PART II

The Disposability of Packaging Materials

The Disposability of Packaging Materials

INTRODUCTION

The objective of the second part of the research effort was to evaluate projected qualitative and quantitative changes in packaging materials from the waste disposal point of view. Our findings are presented in this section of the report.

Disposability is an aspect of packaging materials which has received virtually no attention.* Packaging materials can be measured and described in hundreds of ways to define their characteristics and functions. But their disposability has not been measured. Consequently, the best judgments as to their performance in various disposal processes are fundamentally descriptive and subjective.

The reasons for this situation are not difficult to discover. The packaging industry has never viewed disposability as a criterion of design. On the contrary, the industry's aim has been to create packages that would *not* crush, break, dissolve, bend, fade, collapse, burn, etc. To cite another reason, the serious nature of environmental pollution by solid waste has not become crucial enough to deserve notice until recent years. Solid waste disposal has been and continues to be, characterized by low technological sophistication. One consequence of this has been that disposal system operators have not demanded—and have not had the financial support to develop—information which would clearly define the disposability characteristics of materials in particular processes in a quantitative manner.

Today, a trend away from this state of affairs is discernible. This is a result of growing awareness of solid waste handling problems resulting from burgeoning populations and government interest in this aspect of environmental pollution. This interest has sparked a reaction on the part of the packaging industries; they are concerned about their vulnerability to possible legislation aimed at remedying the situation. A number of industries, either through in-house efforts or through their associations, have appointed senior officials to look into the disposability aspects of the materials manufactured by their particular industry. As a consequence, it appears that the first steps have been taken toward expanding package design criteria beyond strictly functional considerations. To the traditional missions of the packaging materials manufacturer, another may be added: to create a package which is relatively easy to dispose of.

The analysis of packaging material disposability has not been an easy one. A paucity of information and an almost complete absence of precedents and guidelines were the starting points. We were cast into the role of those who must make the first halting efforts toward creating concepts which can then be refined and modified by others.

Three aspects of disposability are discussed in this report: (1) quantities of various materials to be disposed of; (2) collection problems associated with these materials; and (3) the resistance of the materials to processing by present disposal techniques.

DISCUSSION OF DISPOSABILITY

Disposability may have several different meanings depending on the point of view of the observer.

—*For the housewife*, a package is disposable if she can discard it. It is not disposable if she must return it to the store.

—For the *trash collector* all packages are disposable but some configurations are easier to handle than others. Cans and paper bags can be placed into a dump truck or a compactor truck without trouble. Large steel drums pose special handling problems. And wrappers, bottles, and cans strewn along

---

*A distinction must be made between "discardable" and "disposable" containers. In packaging and in popular speech, a "disposable" container is one which may be thrown away or discarded after use. In fact disposal of the container or package may not be easy after it is discarded. Nevertheless discardable packages may be rewarded in the marketplace.

Preceding page blank

highways present special and costly pickup problems.

—For the *operator of a waste processing facility*, disposability of materials will depend on the nature of the process used. Certain noncombustible packages, for example, are undesirable in incinerators but may be entirely acceptable in sanitary landfills.

Given these varied points of view from which disposability can be regarded, together with the large numbers of different materials and configurations of which packaging wastes are composed, it is difficult to express measures of disposability in terms of a single value system. If reliable nationwide cost data on waste disposal in all its aspects—collection, handling and transfer, and disposal or recycle—were available in sufficient detail to permit calculation of costs associated with discrete waste components, it might be possible to express disposability in a single cost figure: so many dollars per ton today, so many dollars per ton tomorrow. Such data, however, are just beginning to be developed and are not expected to be available for some years to come.

The absence of cost information which could be used for determining the relative disposability of packaging materials for the nation as a whole has required an approach involving three separate analyses:

(1) Analysis of the quantity of packaging materials to be disposed of in 1966 and 1976 and the significance of the changes that are anticipated;

(2) Analysis of the collection problems associated with the various materials; and

(3) Analysis of the resistance to disposal of the materials in different waste handling processes.

Before examining these analyses, it would be helpful to understand the complexity of the disposal "system" by which the nation's solid wastes are handled. An overview of the system is presented in Figures 27 and 28. These flow charts omit much detail but they do suggest that there are many alternate routes by which a material can move from the user to ultimate disposal or reuse.

The overall disposal system may be viewed as a complicated "pipeline" with processing facilities at its end. The operator of pipeline and plant is concerned with two basic elements of the "product" he must move and handle: its volume, which determines the capacity of the system . . . and the nature of the product itself which determines the technical design of the facilities; fresh milk, by way of analogy, could not be conveyed in the same system as crude oil.

In this sense, the quantity of waste to be handled represents an overall load on the system irrespective of the routes that may be used or the facilities to which the waste is channeled. The technical parameters are the composition of the materials; shape, size, and configuration of the packages; and the characteristics and behavior of the waste as a whole in a variety of processes and collection systems.

Associated with each element is cost—cost of land, of physical facilities, and operating costs. Ideally, disposability should be gauged in terms of total cost for handling a given material in the system; this is not possible at the present time because even the most rudimentary of surveys—of total waste generation; of types, numbers, and locations of facilities; of total expenditures—are only now beginning to be made, and at present only a small number of states have advanced far enough to have a clear picture of their own disposal systems.

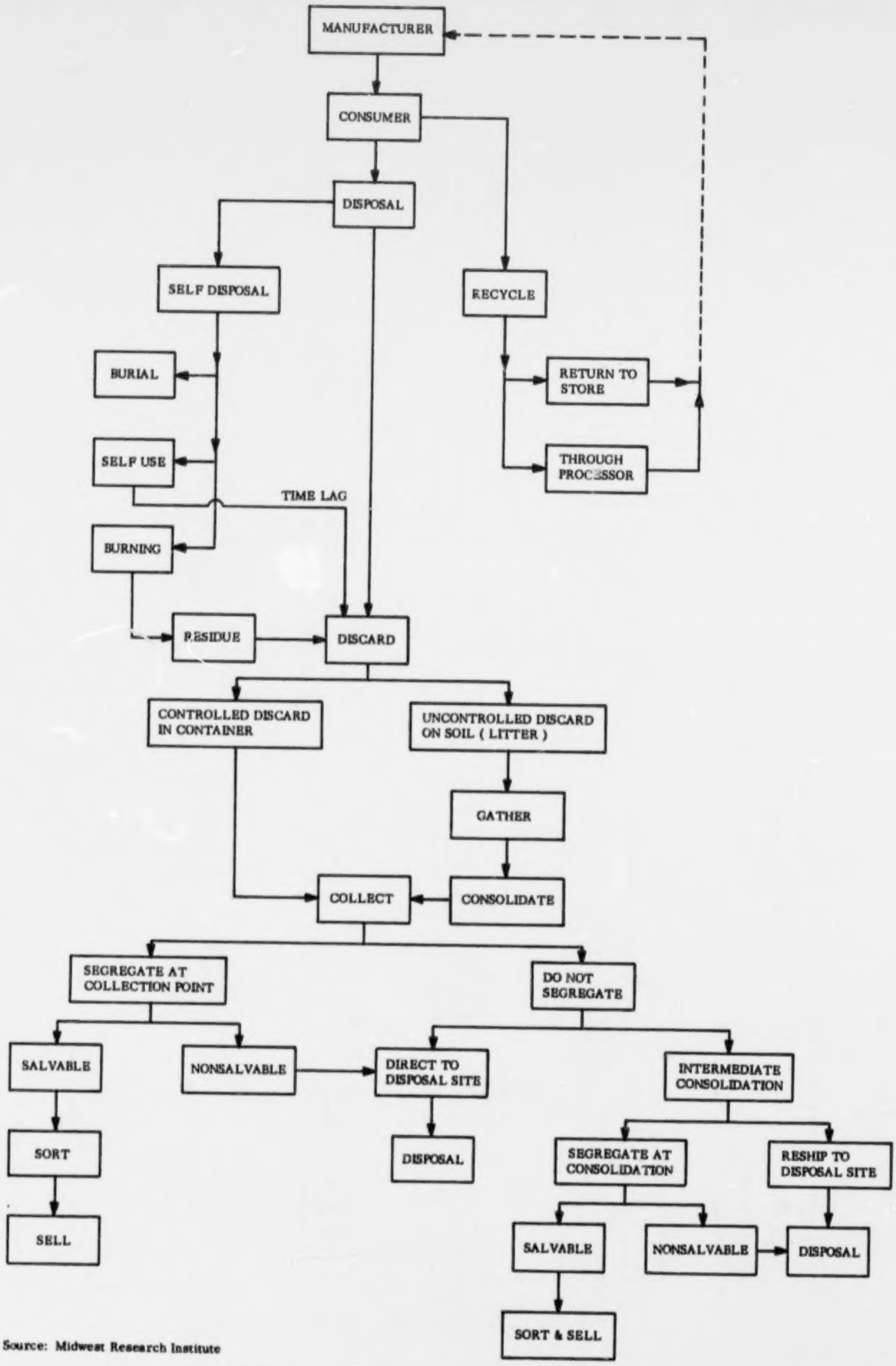
In the absence of cost data it is necessary to make qualitative judgments of the disposability of packaging (or other) materials by measuring quantity and by comparing the relative technical difficulty of processing various materials through present waste disposal facilities.

ANALYSIS OF QUANTITATIVE CHANGES

Packaging Waste in Perspective

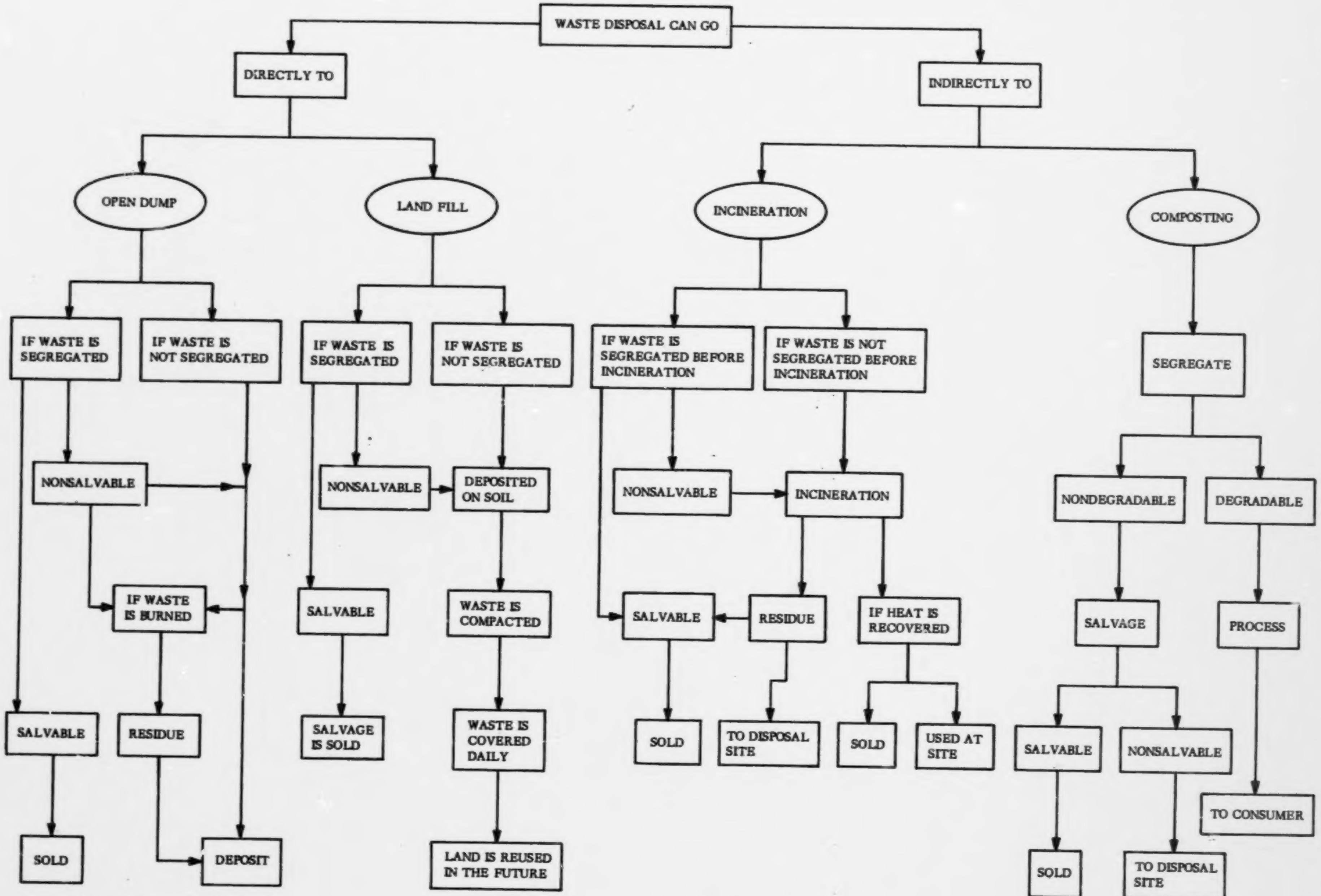
According to our best estimates 350 million tons of solid waste are generated by residential, commercial, and industrial sources in the United States every year. Of this total, residential waste accounts for approximately 160 million tons, and industrial and commercial wastes for about 190 million by weight. Looking at residential and industrial wastes separately, packaging materials accounted for 19.9 percent of residential wastes and 7.7 percent of commercial and industrial wastes. In addition to these tonnages, agricultural and mining wastes, scrapped automobiles, and building rubble must also be disposed of, but these wastes seldom enter normal disposal channels.

Of the 51.7 million tons of packaging materials generated in 1966, only about 10 percent did


MANUFACTURER
CONSUMER
DISPOSAL
SELF DISPOSAL
RECYCLE
BURIAL
RETURN TO STORE
SELF USE
THROUGH PROCESSOR
TIME LAG
BURNING
RESIDUE
DISCARD
CONTROLLED DISCARD IN CONTAINER
UNCONTROLLED DISCARD ON SOIL (LITTER)
GATHER
COLLECT
CONSOLIDATE
SEGREGATE AT COLLECTION POINT
DO NOT SEGREGATE
SALVABLE
NONSALVABLE
DIRECT TO DISPOSAL SITE
INTERMEDIATE CONSOLIDATION
SORT
DISPOSAL
SEGREGATE AT CONSOLIDATION
RESHIP TO DISPOSAL SITE
SELL
SALVABLE
NONSALVABLE
DISPOSAL
SORT & SELL

Source: Midwest Research Institute

Figure 27.—Solid waste flow from consumer to disposal site or recycle


WASTE DISPOSAL CAN GO
DIRECTLY TO
INDIRECTLY TO
OPEN DUMP
LAND FILL
INCINERATION
COMPOSTING
IF WASTE IS SEGREGATED
IF WASTE IS NOT SEGREGATED
IF WASTE IS SEGREGATED
IF WASTE IS NOT SEGREGATED
IF WASTE IS SEGREGATED BEFORE INCINERATION
IF WASTE IS NOT SEGREGATED BEFORE INCINERATION
SEGREGATE
NONSALVABLE
NONSALVABLE
DEPOSITED ON SOIL
NONSALVABLE
INCINERATION
NONDEGRADABLE
DEGRADABLE
IF WASTE IS BURNED
SALVABLE
WASTE IS COMPACTED
SALVABLE
RESIDUE
IF HEAT IS RECOVERED
SALVAGE
PROCESS
SALVABLE
RESIDUE
SALVAGE IS SOLD
WASTE IS COVERED DAILY
SOLD
TO DISPOSAL SITE
SOLD
USED AT SITE
SALVABLE
NONSALVABLE
TO CONSUMER
SOLD
DEPOSIT
LAND IS REUSED IN THE FUTURE
SOLD
TO DISPOSAL SITE

Source: Midwest Research Institute.

FIGURE 28.—Alternative waste disposal routes

not enter the solid waste stream. The remaining 90 percent (46.5 million tons) accounted for 13.3 percent of the Nation's total volume of solid wastes. Residential sources of packaging materials accounted for 31.8 million tons of the total, or 9.1 percent; industrial and commercial sources for 14.7 million tons, or 4.2 percent.

The 5.2 million tons of packaging material that did not enter the solid waste stream in 1966 were recycled materials, consisting primarily of paper. The paper component of this total amounted to 4.8 million tons—3.2 million tons of containerboard and 1.6 million tons of other packaging paper. Other materials—metals, glass, plastics—constituted the remaining 0.4 million tons.

While recycling directly reduces the quantities of packaging materials requiring ultimate disposal, there is another factor that affects the disposal of packaging materials that are consumed in any one month or year. Some materials are delayed from entering or are diverted entirely from entering the solid waste stream. This factor introduces the time element and recognizes that not all packaging material becomes waste in the year it is consumed. For instance, some packaging is reused in its original configuration or is put to secondary uses or is permanently retained for some reason. Examples of some of these items are steel drums and pails, fiber drums, returnable bottles, wood boxes, textile bags, gas cylinders, pallets and skids, paperboard boxes and specialized glass containers.

Also, at any time, a consumer or business might have a diverse inventory of boxes, plastic and glass containers, wrapping paper, sacks, cans and the like in some secondary use. However, these items are not usually accumulated in large numbers and are rapidly discarded or replaced. (An example would be a housewife who saves sturdy corrugated containers for use as mailing containers or uses glass jars for food storage.) Nonetheless, these materials are discarded at about the same rate as they are accumulated with only a minute number permanently diverted in one year.

Therefore, all practical purposes we found no basis on which to differentiate this latter group because of its insignificant impact on the total quantity of materials. Thus, with the exception of recycled materials all packaging is considered to enter the solid waste stream in the same quantity it is produced in any one year.

The costs of collection and disposal of solid wastes were estimated at $3.2 billion in 1966, an average of about $9 per ton across the nation. Costs fluctuate widely from location to location and may reach $25 per ton in certain areas.

On the basis of $9 per ton for collection and disposal, the 1966 packaging materials volume cost the nation $149 million to process from the user to ultimate disposal (including recycling).

By 1976, residential waste tonnage is expected to reach 215 million tons. Packaging wastes weighing 45.2 million tons will be a part of this tonnage, representing 21 percent of the total. We have no forecasts of industrial waste generation in 1976. Packaging wastes from industrial and commercial sources, however, including salvaged materials, will have increased from 14.7 million tons in 1966 to about 21 millions tons in 1976.

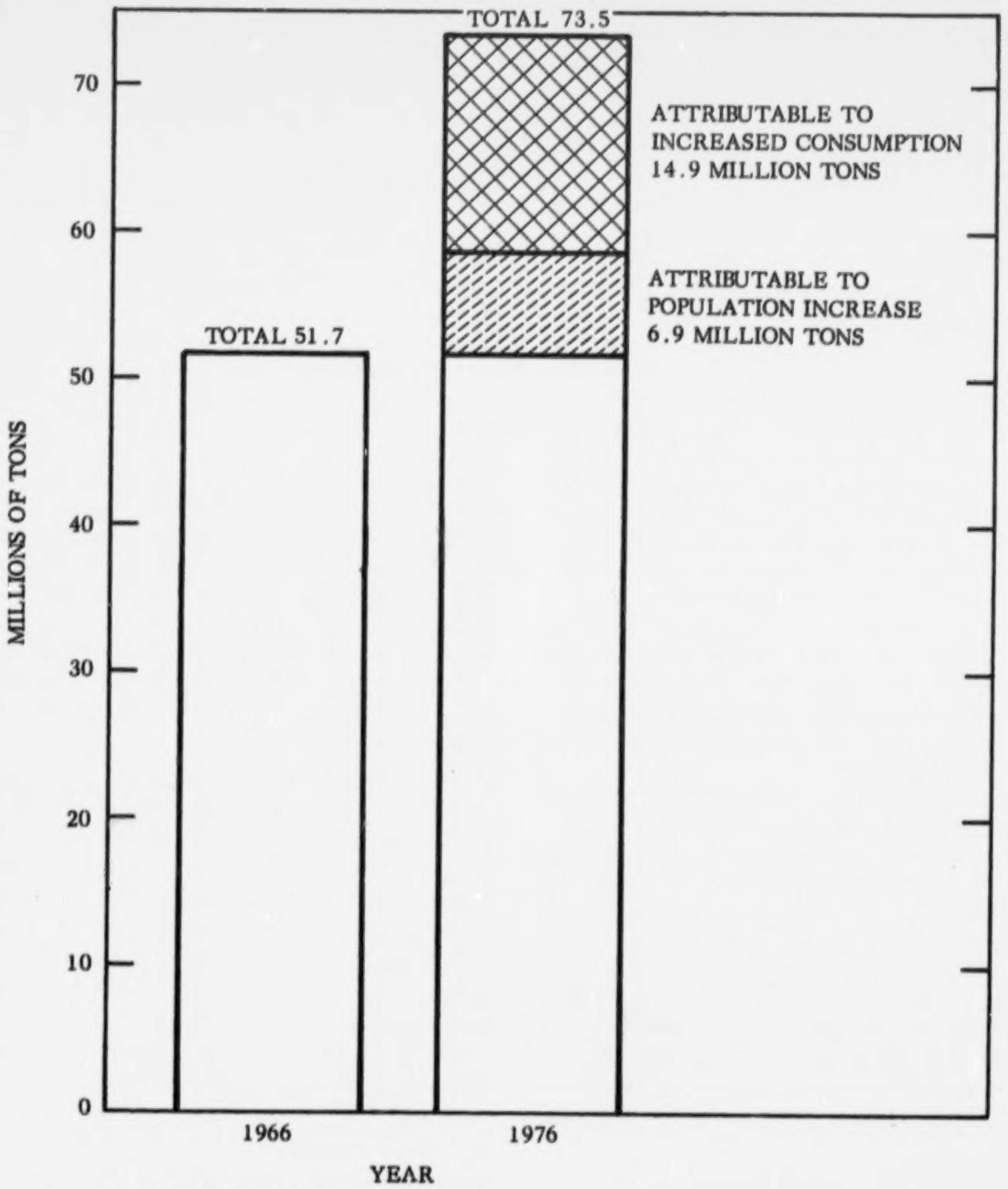
Disposal costs for packaging materials will rise from $419 million to $595 million, assuming no increase in the costs of collection and disposal, which is unlikely. In fact, the unit costs of handling packaging wastes will exceed the $9 a ton mark for three reasons: labor costs are expected to increase; the waste will be less dense; and more sophisticated processing facilities will be used (incineration and sanitary landfill in place of opening dumping).

Absolute and Relative Increases

Packaging materials volume will rise from 51.7 million tons in 1966 to 73.5 million tons in 1976, an increase of 21.8 million tons. About a third of the increase, 6.9 million tons, will be accounted for by population expansion; about two-thirds of the increase, 14.9 million tons, will be generated by changing consumer habits which increase consumption per capita (Figure 29).

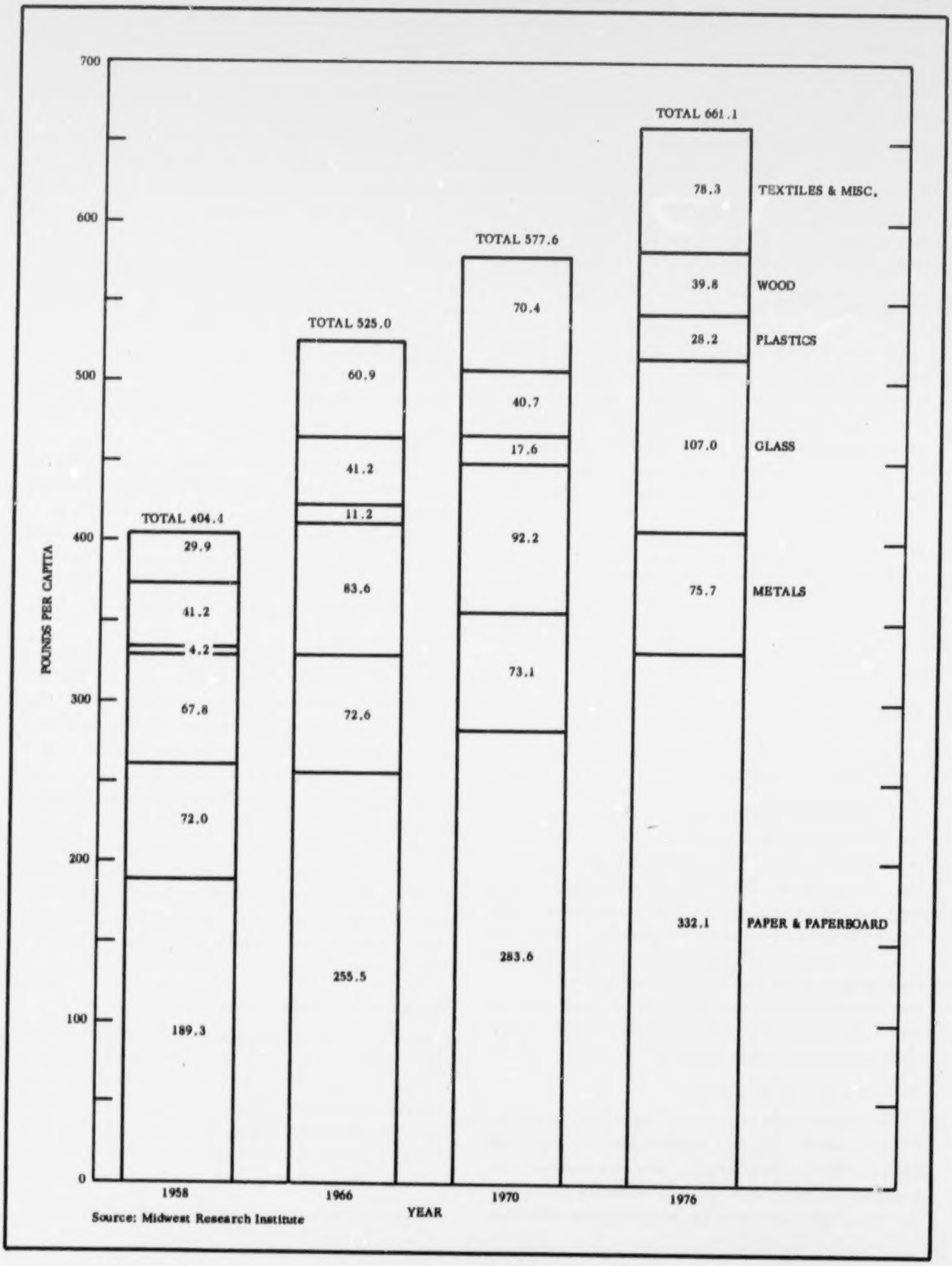
Actual per capita consumption in 1966 was 575 pounds. This is expected to increase to 661 pounds by 1976 (Figure 30). This means that, on an average, each man, woman, and child in 1976 will use 136 more pounds of packaging material than he used in 1966.

This projected increase in per capita consumption of packaging materials is actually quite conservative when viewed in historical per-



Source: Midwest Research Institute

Figure 29.—Consumption of packaging materials: 1966 and 1976 (millions of tons)



Source: Midwest Research Institute

FIGURE 30.—Consumption of packaging materials: 1958–1976 (pounds per capita)

spective, as shown below (Table 67) in comparison with the recent past.

Table 67.—*Average annual increase in per capita consumption of packaging materials: 1958 to 1976*

Year	Average annual increase
1958 to 1966	2.7 percent
1960 to 1966	2.9 percent
1966 to 1976	2.3 percent

Source: Midwest Research Institute.

Turning to individual packaging materials, the most significant per capita percentage gains will be made by plastics, paper, glass, and metals in that order. Wood and textiles will decline. Per capita increases of these materials in the period 1966 to 1976, expressed both in pounds and as a percentage of 1966 volume, are shown in Table 68.

Table 68.—*Increase in per capita consumption of packaging materials: 1966 to 1976*

Material	Per capita increase in pounds 1966 to 1976	Increase as a percent of 1966 consumption
Plastics	17.0	152
Paper	76.6	30
Glass	23.4	28
Metals	3.1	4

Source: Midwest Research Institute.

It should be noted that in these and other forecasts, population projections of the C series published by the U.S. Department of Commerce have been used. The Series C projections are next to the lowest of the four projections made by the Bureau of Census. We believe it to be the most reasonable. If population growth exceeds that projected in the Series C tables, per capita consumption would remain relatively unchanged; but total packaging volume would trend higher than projected in this analysis.

Significance of Findings

The significance of these findings for the operator of a waste disposal facility may be summed up as follows: packaging waste generation will continue to grow at a rate substantially exceeding normal population growth, requiring the addition of waste collection and disposal plant capacity for packaging materials at a rate of 2.3 percent annually in the 1966 to 1976 period just to accommodate industrial and consumer purchasing habits.

Also implied in the quantitative analysis are other factors which will be discussed at greater length below. Among these: (1) wastes will be more costly to collect per pound because they will be lower density; (2) the proportion of difficult-to-handle materials, especially plastics, will increase; (3) the amount of land necessary to store and/or process these materials for ultimate disposal will nearly double; and (4) the volume of salvagable materials in the waste will increase substantially.

ANALYSIS OF COLLECTIBILITY

Collection in Perspective

Collection of wastes is by far the most costly aspect of waste disposal. Nearly 90 percent of all expenditures on waste processing are attributable to pickup and transportation of wastes. The total spent on collection by the nation has been estimated at approximately \$2.8 billion.[1]* Of this total, packaging materials accounted for \$373 million.

Another way to illustrate the size and complexity of the collection function in the United States is to look at total vehicles used. In 1966 approximately 150,000 trucks were operated exclusively for trash and garbage pickup, about one-third by municipalities, the balance by private contractors.[2] The overwhelming majority of these vehicles were closed-body compactor trucks capable of carrying three times the load haulable by noncompactor types. In addition, another 85,000 vehicles (sedans, pick up trucks, construction vehicles, etc.) were also operated by solid waste agencies and contractors in their collection and/or disposal operations.

Some Basic Distinctions

In order to make a judgment about the relative collectibility of packaging materials in 1976 as compared with 1966, some basic distinctions concerning collection problems must be pointed out.

One fundamental difficulty connected with collection falls outside the effective control of the package manufacturer and the disposal agency and arises exclusively from sociological factors; that is, the cooperation of the public in the actual disposal of its wastes.

---

*Reference citations are listed at the end of the report.

This can be illustrated by considering the vast difference in difficulty and cost between collecting one ton of cigarette wrappers discarded in trash containers and one ton of wrappers casually thrown from the windows of cars along highways and streets. In the first instance, we are faced with a simple collection task. In the second, we are faced with littering. Thus, the same material or package may have a radically different degree of collectibility depending on whether it is discarded under controlled or uncontrolled circumstances.

A second area of distinction is between volume and the technical characteristics of the waste. Assuming, for instance, that packaging wastes do not change in composition between 1966 and 1976, the total volume would be more difficult to collect a few years hence because there would be much more of it. Assuming that the volume remains the same, collectibility of a ton of waste may become more difficult nevertheless, because of compositional and configurational changes.

Our analysis of collectibility recognizes these distinctions and each area singled out above is separately discussed.

Litter

Packaging materials apparently constitute a large part of the total litter to be found in the United States. Two well-known litter surveys—one in Kansas and another in Vermont—would seem to establish that fact beyond any reasonable doubt.

The Kansas survey listed 3,086 items (Table 69) found along a one-mile stretch of a two-lane highway. Of these, 2,036 (65 percent) were discarded packages; if the 770 paper cups found are also listed as packaging materials, the percentage jumps to 88 percent.

Table 69 shows that the bulk of items discarded (2,540 items or 82 percent) as used to convey or to dispense beverages and cigarettes, with beverages making up the lion's share of the total.

Vermont's State Litter Commission, whose survey (conducted in the mid-1950's) was considerably more extensive and included all litter accumulations across the State, also placed paper and metal packaging materials high in overall volume. Glass containers ranked lowest, probably because of a four-year ban (1953 to 1957) on the sale of nonreturnable glass beverage containers in Vermont.[3]

TABLE 69.—*Survey of litter found along a one-mile stretch of two-lane highway in the State of Kansas*

770 paper cups
730 empty cigarette packages
590 beer cans
130 pop bottles
120 beer bottles
110 whiskey bottles
90 beer cartons
90 oil cans
50 paper livestock feed bags
30 paper cartons
26 magazines
20 highway maps
16 empty coffee cans
10 shirts
10 tires
10 burlap bags
4 bumpers
4 shoes—no pairs
2 undershirts
2 comic books
2 bed springs
270 miscellaneous items

Source: John E. Evans. The beer man's guide to lessening litter. New York, Glass Container Manufacturers Institute, undated, p. 5.

Analysis of these survey findings in light of expected future trends in packaging would suggest that litter volume may rise rather sharply during the next 10 years, unless some kind of national conscience can be developed to inhibit such carelessness.

The basis for this judgment is that consumption of beverage containers per capita will increase dramatically in the future as nonreturnable containers capture larger shares of the beer and soft drink markets. The increases in consumption may be shown most tellingly by a look at per capita consumption of beverage containers (Table 70).

This growth in the consumption of beverage containers—which constitute a large proportion of the packaging litter—will be accompanied by a rise in the car population from 35 cars per 100

TABLE 70.—*Per capita consumption of beverage containers: 1966 and 1976*

Type of container	Consumption per capita in units		Percent increase
	1966	1976	
Wine and liquor	12.9	13.8	7.0
Beer	28.5	40.8	43.2
Soft drinks	19.8	66.1	233.8
Total beverages	61.2	120.7	97.2

Source: Compiled by Midwest Research Institute.

people in 1966 to 44 cars per 100 people in 1976. This is significant because littering and motoring are related activities.

Volume

The problem of volume faced by waste collectors as a result of packaging material consumption changes in the 1966 to 1976 period may be summed up briefly. Collection systems operators will have to haul about 19.6 million tons more of these materials in 1976 than in 1966 (90 percent of the 21.8 million increase).

Assuming an average capacity of four tons per truck, the national increase in packaging materials volume will necessitate nearly 4.75 million more collection trips in 1976 than were required in 1966. Assuming a work year of 250 days and two trips per truck to a disposal site, 9,500 new compactor trucks will have to be added to the collection vehicle population by 1976 to convey just the *increase* in packaging materials expected by then. If additional trucks need to be purchased, investment costs necessary to obtain the required carrying capacity by 1976 would amount to between $135 and $190 million at present prices.

Other Factors Affecting Collectibility

Two closely related characteristics of packaging material waste are of particular importance from a collection point of view: density and compactibility.

A material which takes up fewer cubic yards per ton is more collectible than one which takes up more space. This is because the *space capacity* of the collection vehicle—nearly always the limiting factor—is better utilized with denser materials. Fewer trips have to be made to haul a given tonnage, and costs are consequently lower.

Where materials have the same natural density, configurations which are compressible are favored over those which resist compaction.

These collection criteria permit another approach to the evaluation of collectibility on the basis of density and compactibility. Compactibility may be included in a general evaluation of collection since the overwhelming majority of collection vehicles in use are compactor types.

Packaging material waste, viewed as a whole, is a heterogeneous mixture of paper, metal, glass, plastic, wood, and textile packages in thousands of configurations. A ton of representative material on the basis of 1966 and 1976 distributions is shown in Table 71.

Table 71.—*Composition of a ton of packaging materials: 1966 and 1976*

In Pounds

Type of material	1966	1976	Percent change over 1966
Paperboard	650	734	12.9
All other paper	446	404	9.4
Metals	312	260	16.7
Glass	358	366	2.2
Wood	176	136	−22.7
Plastic films	28	44	57.1
All other plastics	20	52	160.0
Textiles	10	4	−60.0
Total	2,000	2,000	....

Source: Midwest Research Institute.

The change in composition of this representative ton of packaging materials between 1966 and 1976 is significant in that a decline in average density will take place. Assuming that the materials are compressed to their natural density—a fully densified state with all air space eliminated—the 1966 ton would take up 29.9 cubic feet (1.1 cubic yards); but the 1976 ton would take up 31.2 cubic feet (1.2 cubic yards), an increase of 4 percent.

Another way to put it: in 1966, a cubic yard of packaging materials compressed to natural density would weigh 1,782 pounds; in 1976, a cubic yard would weigh 1,728 pounds or 54 pounds less.

Unfortunately, complete densification cannot be achieved by compaction, so our analysis must be tailored to the actual capabilities of present day compaction equipment. Household refuse in the garbage can usually weighs around 175 to 225 pounds per cubic yard. At 100 pounds per square inch (psi) pressure, the density of this refuse exceeds 1,400 pounds per cubic yard under laboratory conditions. Compactor truck mechanisms can exert maximum pressures ranging up to 27 psi, which would result in a density of about 800 pounds per cubic yard for compacted household refuse; in most cases, however, densities of around 400 pounds per cubic yard are more usual.

Discarded packaging materials are classified as rubbish, and rubbish is generally of lower density than mixed household refuse which may include ashes and garbage. Uncompacted rubbish densities may vary from 60 to 600 pounds per cubic yard depending upon its material composition, water content, and the degree to which it is compressed in the rubbish container by the householder.

The difficulty of determining the uncompacted density of packaging materials may be illustrated by a look at metal cans. A cubic yard of steel and aluminum cans (mixed in proportion to their present market shares), would weigh slightly more than 300 pounds uncompacted if the cans were carefully and tightly stacked (see Table 72 for basic data used in calculation). In such a case, nearly 98 percent of the space would be taken up by air within and between the empty cans. A cubic yard of such a mixture of steel and aluminum cans compressed to natural density (complete solidity) would weigh more than 12,700 pounds or over 6 tons! It is easy to see that a housewife who flattens her tin cans before throwing them away can materially reduce the volume of her trash, and thereby contribute significantly to the relief of waste collection and disposal problems.

TABLE 72.—*Shipments of metal cans by end-use markets: 1965*

End-use market	Percent of shipments [a]	Representative capacity in fluid ounces
Fruit, vegetables, soups, juice...	29.2	10
Evaporated, condensed milk....	3.2	4
Other dairy products...........	.4	4
Meat, including poultry........	2.9	10
Fish, seafood..................	2.5	4
Coffee.........................	3.7	32
Lard, shortening...............	1.6	32
Soft drinks....................	6.4	12
Beer...........................	18.9	12
Pet food.......................	4.2	15
Oil cans.......................	2.6	32
All other food.................	11.7	15
All other nonfood..............	12.7	16
Total..................	100.0	....

[a] Base boxes of metal.

Source: Can Manufacturers Institute, *Annual Report—Metal Can Shipments—1966*. Washington, D.C. 1967, Midwest Research Institute.

Although many factors in the shifting mix of packaging material subcategories are expected to influence compactibility, most of the increase in difficulty can be traced to a few basic changes:

—Paperboard, which is more difficult to compact than other types of paper packaging, will represent a higher percentage of total paper and paperboard tonnage, 79.2 percent in 1976 versus 75.8 percent in 1966.*

—Easily compactible metal cans will decline in share of the market from 11.6 percent by weight of packaging materials in 1966 to 9.9 percent in 1976.

—The decline in metals will not be made up by the increase in glass, also a readily compactible material. Glass will increase from 17.9 percent to 18.3 percent.

—Plastic film, whose compactibility is poor because of its resilient nature, will increase its share from 1.4 percent to 2.2 percent: total plastics will increase from 2.4 percent of total in 1966 to 4.8 percent in 1976.

Significance of Findings in Collection

For the manager of a municipal collection system or for his counterpart in private business, the significance of these findings may be summed up as follows:

Expected quantitative and qualitative changes in packaging materials consumption in the 1966 to 1976 period will:

(1) Intensify the litter problem primarily by providing greater quantities of nonreturnable beverage containers;

(2) Call for the addition of new equipment to handle a 19-million ton increase in packaging refuse alone; and

(3) Render collection more difficult because the waste will be less dense and more difficult to compact.

ANALYSIS OF RESISTANCE TO DISPOSAL

Disposal Methods in Perspective

Waste materials must sooner or later be disposed of by one or two routes—by deposition on the soil or by conversion into gases which become part of the atmosphere. Of these, only the first route can serve as a complete ultimate disposal method. Even when wastes are incinerated, ash residues are left over which must be deposited on the soil. Fly ash and dust which escape to the atmosphere must eventually also settle out on land or surface water.

---

*Concerning compaction see the discussion and qualifications on page 124.

Ignoring ocean disposal, disposal on the soil, or ultimate disposal, can take two forms. The waste can simply be dumped on the land with little or no attempt to modify its appearance by compaction or burial. However, dumping on land may also be practiced under controlled circumstances, whereby the wastes are first dumped, then compacted, finally covered with an inert fill material. This technique is called sanitary landfilling.

Wastes may be incinerated as a step to reduce their bulk and weight. Excluding open burning—which is practiced at some dumps—incineration is practiced by three sectors of the economy: cities, which employ municipal incinerators; commercial and industrial firms which practice on-site incineration; and the public itself, which burns wastes in outdoor burners or apartment house incinerators where such disposal is permitted.

Additionally, wastes may be reduced in a composting plant where most of the material is converted to a useful soil conditioner, another portion is salvaged, and the remainder is disposed of by dumping or incineration; if incineration is used, residues must once more be disposed of.

Finally, salvage operations can also be used to reduce the amount of waste which must reach ultimate disposal. Salvage may take place at various points in the disposal chain: (1) at the point of storage, collection, or transfer; (2) at the dump or landfill site; (3) in conjunction with incineration—before and after burning; (4) in conjunction with composting; and (5) as an independent disposal activity. Salvage, by its very nature, implies that large quantities of useless materials will be left over which must be handled by some other means.

Of these reduction and disposal processes, by far the most common is open dumping. It accounts for nearly 80 percent of all waste disposed of. Strictly speaking, open dumping is not a disposal technique so much as a form of controlled, and in many cases, uncontrolled storage. Wastes are simply deposited in an area. The foremost "technical" considerations in open dumping are locational: the site should be located close enough to the collection area to be accessible, far enough away from residential or business districts so as not to generate too many complaints, located in such a manner as to be hidden from sight, and located downwind from inhabited areas to prevent the drift of smoke and/or odors into built-up areas.

It is readily apparent that the costs associated with this method are quite low in comparison with techniques where considerably more processing of the material is required.

Open dumping is cheap but it is also undesirable. We foresee the progressive elimination of open dumps in coming decades in continuation of an established trend. This trend alone will have the greatest single impact on waste processing in the next 10 years: a growing tonnage of waste will be handled by processes which are substantially more costly than dumping.

A comparison of the relative dominance of disposal methods in 1966 and 1976 is shown in Table 73. Here the percentages shown refer to waste tonnage handled by each technique. All incinerated waste tonnages are combined in a single figure, regardless of the sector in which they were disposed of (cities, industry, public). In 1966, approximately 6 percent of total waste was incinerated in municipal, commercial, industrial, and apartment house incinerators; about 8 percent was disposed of in backyard, household, and burners.

The percentages shown in the table are based on all residential, institutional, commercial, and

TABLE 73.—*Relative dominance of disposal methods: 1966 and 1976*

Disposal method	Percent of solid waste tonnage handled	
	1966	1976
Incineration [a]	14.0	18.0
Sanitary landfill [b]	5.0	13.0
Open dumping [c]	77.5	64.0
Composting	.5	1.0
Salvage [d]	3.0	4.0
Total	100.0	100.0

[a] Includes all disposal by burning—municipal, commercial, industrial, apartment house, and backyard household burners—except burning operations at open dumps or on seagoing barges.

[b] Strictly defined; waste is covered daily.

[c] Includes open dumping, ocean dumping, and casual dumping (litter); burning of waste may be practiced in conjunction with open dumping.

[d] Includes all operations where salvage is practiced, including salvage operations in conjunction with composting, incineration, landfilling, collection, etc.

Source: Midwest Research Institute.

conical industrial wastes. Demolition wastes, abandoned automobiles, agricultural wastes, and mining wastes, are excluded.

Discussion of Processes and Materials

The purpose of this section is to discuss in detail the roles played by various materials in the different processes, and to present quantitative information on which the ranking system presented in the next section, was based. A brief discussion of each process is presented, together with an evaluation of the suitability of the various materials for disposal by that process.

Incineration

Refuse incineration is the best technique for reducing the volume and weight of waste materials. Volume reduction for all wastes ranges from 70 to 80 percent, while weight reduction of between 60 and 80 percent can be achieved.

The single most important characteristic a material can possess for suitability in this process is combustibility.

With the exception of glass and metal containers, all packaging materials will burn, albeit at different rates. Paper, textiles, wood, and plastics are all combustible (especially when dry), although plastics generally have lower burning rates than the other materials. Most incineration problems are associated with the fact that metals and glass are unsuitable for the process and with the fact that the refuse incinerated varies widely in composition. Consequently, different burning rates of refuse components can have an adverse effect on the incinerator's performance. A truckload of plastic containers, for instance, can cause a good deal of trouble whereas occasional plastic containers representing a small portion of a total load cause no difficulty whatever.

A second major material characteristic governing its suitability for incineration is the inert residue it leaves. A ton of packaging materials, containing representative proportions of all materials, will leave a residue of approximately 705 pounds after incineration. Of this total, 637 pounds (or 90 percent) are accounted for by metal and glass containers. Since paper is expected to increase its proportion of the total by 1976, the inert residue of a representative ton of materials should decline to 672 pounds. Metals and glass will account for an estimated 598 pounds, about 89 percent of the residue (Table 74). Clearly, removal of glass and metal containers from packaging wastes to be incinerated would virtually eliminate the secondary disposal problem associated with the incineration of packaging wastes.

A number of other parameters for judging packaging materials in incineration were also used in this evaluation: Btu content of the materials, sulfur content, and potential damage to equipment.

Btu content (Table 75) is significant in incinerator operations if waste heat from burning is recovered for use. Waste heat recovery is not

TABLE 74.—*Inert residue of a ton of packaging materials by material: 1966 and 1976* [a]

Material	Percent inert residue	1966				1976			
		Share of total packaging waste		Residue in pounds	Percent of residue contributed to total	Share of total packaging waste		Residue in pounds	Percent of residue contributed to total
		In percent	In pounds			In percent	In pounds		
Paperboard [b]	3.57	32.5	650	23.2	3.29	36.7	734	26.2	3.90
All other paper	7.65	22.3	446	34.1	4.84	20.2	404	30.9	4.60
Metals	90.49	15.6	312	282.3	40.03	13.0	260	235.3	35.00
Glass	99.02	17.9	358	354.5	50.26	18.3	366	362.4	53.92
Wood	2.89	8.8	176	5.1	.72	6.8	136	3.9	.58
Plastic films	6.72	1.4	28	1.9	.27	2.2	44	3.0	.45
All other plastics	19.72 [c]	1.0	20	3.9	.55	2.6	52	10.3	1.53
Textiles	3.17	.5	10	.3	.04	.2	4	.1	.02
Total		100.0	2,000	705.3	100.00	100.0	2,000	672.1	100.00

[a] Based on 1966 and 1976 material tonnage shares. See Table 71.

[b] Containerboard, special foodboard, and set up boxboard only.

[c] In test batch, this category included rubber, leather, plastics heavier than films, and shoes; as a consequence the residue percentage may not be accurate as to heavy plastics alone.

Source: Elmer R. Kaiser. Composition and combustion of refuse. *In* Proceedings, MECAR Symposium, Incineration Committee, ASME Process Industries Division. New York, 1967, p. 4. Midwest Research Institute.

Table 75.—*Heating values of packaging materials: 1966*

In Btu per pound

Material	As received basis	Dry basis
Paperboard	6, 389	7, 841
All other paper	5, 390	7, 793
Metals [a]	683	742
Glass [a]	79	84
Wood	6, 850	8, 236
Plastic films	11, 138	13, 846
All other plastics [b]	6, 778	9, 049
Textiles	5, 876	8, 036

[a] Btu in labels, coatings, and remains of contents.

[b] Test batch included rubber, leather, plastics heavier than films, and shoes.

Source: Elmer R. Kaiser, "Composition and combustion of refuse. *In* Proceedings of MECAR Symposium, Incineration Committee, ASME Process Industries Division. New York, 1967. p. 4.

commonly practiced in conjunction with U.S. incineration; but in Europe waste heat is generally recovered. Since it seems probable that this practice will also be adopted more frequently in the U.S. in the future, Btu content of materials was made one criterion for the evaluation of materials.

The most accurate measures of air pollutants generated by the incineration of packaging materials would be actual analysis of off-gases obtained under all conditions of moisture content and operating temperatures from the combustion of material batches composed of representative proportions of materials.

Such data are not available. However, in an attempt to measure the air pollution potential associated with packaging materials, we have used sulfur content as a rough measure. Packaging materials are generally low in sulfur content: a ton of representative material contains just under 2 pounds of this substance. By 1976, the total will increase slightly (Table 76). However, far more significant, from an air pollution control point of view, is the pollutant load emitted to the atmosphere as a result of the incomplete combustion of refuse in normal incinerator operations—carbon monoxide, unburned hydrocarbons-toxic nitrogenous compounds, particulates, etc.

Almost any material can cause damage to incineration equipment or interfere with smooth operations if the incinerator is not operated properly. Some materials can cause difficulty merely by appearing in higher concentrations than anticipated in the incinerator fuel and operating specifications.

Table 76.—*Sulfur content of a ton of representative packaging materials: 1966 and 1976* [a]

Material	Sulfur content percent by weight, dry basis	Sulfur content, in pounds, 1966 tonnage share basis	Sulfur content, in pounds, 1976 tonnage share basis
Cardboard	0. 14	0. 91	1. 03
All other paper	. 12	. 54	. 49
Metals	. 01	. 03	. 03
Glass	. 00		
Wood	. 11	. 19	. 15
Plastic films	. 07	. 02	. 03
All other plastics [b]	. 55	. 11	. 29
Textiles	. 20	(c)	(c)
Total		1. 80	2. 02

[a] Based on 1966 and 1976 material tonnage shares.

[b] Test batch, included rubber, leather, plastics heavier than film, and shoes.

[c] Insignificant.

Source: Elmer R, Kaiser. "Composition and Combustion of Refuse. *In* Proceedings, MECAR Symposium, Incineration Committee, ASME Process Industries Division. New York, 1967. p. 4.

Among packaging materials, glass can present an incineration problem regardless of package size or shape in well-run municipal or industrial incinerators. Glass may liquefy and then deposit on the incinerator wall and floor surfaces, forming a bond with the firebrick which is greater than the adhesion of the brick itself. When these surfaces are cleaned, they are unavoidably eroded. This problem appears to be most common in incinerator operations where the combustion takes place at temperatures of 1300°F air temperature and above. It may be noted that few incinerators are operated at design temperatures; consequently, in practice, glass usually appears as inert residue rather than as a deposit on the refractory lining.

Plastics tend to create problems at low-temperature points in an incinerator. They melt, flow down to the grates, and coming in contact with cool air entering the burner, they solidify again, clogging the grates. Such problems are typically associated with heavier rigid and flexible plastics such as bottles and tubs. Light plastics—films, coatings, sacks, etc.—do not cause the same difficulties.

Steel containers are not reported to cause damage or difficulties unless they are over-size. There is some indication, on the other hand, that the presence of steel cans (and open-end glass jars) can have a beneficial effect by creating hollows in the refuse, thus aiding air movements and combustion. Aluminum cans are reported to behave like the heavier plastics.

Sanitary Landfilling

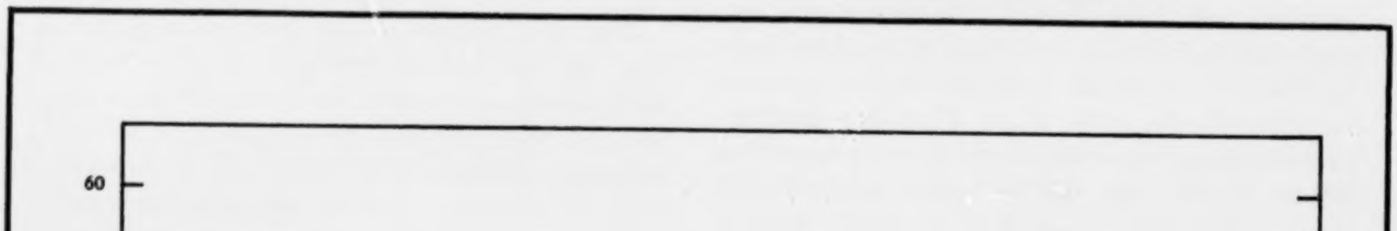
In sanitary landfilling, the basic objective is to store—trouble-free—as much refuse as possible on a given piece of land. Obviously, a material which has a high density when compacted is desirable. Similarly, given two materials with the same density, the one which is more easily compacted and retains its compacted shape is more suitable for landfilling than one which requires greater force for compaction and/or tends to spring back when pressure is released.

The solid density of packaging materials varies considerably—from 480 pounds per cubic foot for steel to 37 pounds for wood. To put it another way, more than 13 tons of solid steel can be placed within the space required for a ton of solid wood (Table 77, Figure 31).

TABLE 77.—*Density of solid packaging materials*

Material	Specific gravity	Density (lb/cu ft)	Cubic feet per ton of material
Aluminum	2.70	168	11.9
Steel	7.70	480	4.1
Glass	2.50	156	12.8
Paper	0.7 to 1.15	44 to 72	45.4 to 27.7
Cardboard	.69	43	46.5
Wood	.60	37	54.0
All plastics (average)	N.A.	71	28.1
Polyethylene	.94	59	33.8
ABS	1.03	64	31.2
Acrylic	1.18	64	27.0
Polypropylene	.90	56	35.7
Polystyrene	1.05	65	30.7
PVC	1.25	78	25.6
PVDC	1.65	103	19.4

Source: Compiled by Midwest Research Institute.



Source: Midwest Research Institute

FIGURE 31.—Volume of one ton of various packaging materials compressed to solid density

Viewed overall, the increases in market shares of paper and plastics—two lightweight materials—are sufficient to reduce the average weight of packaging materials significantly between 1966 and 1976. Since the lighter materials are generally less easily compactible (owing to much greater bulk and increased spring-back), packaging materials on an average will become increasingly resistant to sanitary landfilling during that period.

Judgments measuring relative compactibility of packaging materials were largely subjective. The only objective method of determining compactibility appears to be actual empirical determination of the bulk modulus of specific package configurations. Such a task appears excessively tedious and impractical since, in the reality of landfill operations, materials are not neatly segregated. Materials arrive at the landfill site in a heterogeneous mass: bottles and cans are mixed liberally with paper, yard clippings, rubble, ashes, plastics, and food wastes. Containers are not separately handled and may well be bridged over or otherwise protected from compaction pressure by other objects in the waste. Thus, it is entirely possible that glass which would crush, cans which would flatten, and plastic boxes which would break under known pressures in the laboratory would retain their uncompacted form under even greater pressures in an actual landfill situation. Plastic films, plastic bottles, and paper which would exhibit considerable spring-back under laboratory conditions would not be permitted to regain their natural dimensions in a landfill owing to the weight of other refuse on top.

For many such reasons, the compaction ratings assigned to packaging materials and presented below—generally on the basis of configurations and composition—should be viewed with caution.

Degradability is another basic characteristic of materials well suited for sanitary landfilling. The reason for this is the fact that many landfills are destined to become sites for future construction or recreation activity. It is desirable that the "soil" of such a site be as homogeneous as possible and that tell-tale "dump" traces should not show up objectively when construction begins.

Two types of "degradability" were used in our evaluation: biodegradability and chemical oxidation. This twofold categorization was made in order to acknowledge the fact that containers and packaging materials will decompose in soil by rusting in time, thereby slowly losing their characteristic configurational shapes. Biodegradability pertains mainly to organic packaging materials which can be attacked and reduced by bacterial life in the soil.

On the whole, packaging materials are not very degradable, and this includes *all* materials, not merely those which resist every kind of bacterial or chemical action. Paper, the most degradable of the major-category materials, has been reported to persist unchanged in landfills for 60 years or longer. Not all the paper in such cases remains, but recognizable portions can still be found after long periods of time. Composting operators report that paper is the last material attacked by bacteria in the composting process. Bacteria prefer organic wastes such as garbage. Most other packaging materials resist the action of the soil even more effectively than paper.

Open Dumping

The very nature of the analysis undertaken here—an attempt to measure the *resistance* of materials to processing—has prevented the assignment of values to open dumping in that no direct technical resistance of materials can be associated with a "process" wherein no processing takes place in any conventional sense. Several facts, however, should be noted in connection with open dumping.

The true costs of this disposal technique tend to be hidden—they are more likely to take the form of *indirect* costs than direct expenditures on materials handling and processing. Such costs would include values associated with aesthetic enjoyment of the environment, damages caused by air pollution, potential fire damage from burning which goes out of control, reduction of visibility in the surroundings, nuisance caused by objectionable odors, health hazards brought about by insect and rodent breeding, groundwater and run off pollution, property value losses, and other similar considerations.

If it were possible to assign dollar values to these deprivations, hazards, damages, and nuisances, open dumping might well emerge as the most costly of the disposal processes. Since these costs are not directly measurable, they must be paid by the public in an indirect fashion.

The undesirability of open dumping is less attributable to the wastes involved than to the nature of the technique which is just not suitable from the standpoint of environmental health. Since packaging materials are generally clean, in and of themselves, they would not be expected to contribute to the health hazards of open dumping. Nevertheless a function of packaging materials is to contain or hold products, and their residual contents can cause problems, e.g., where food products are involved. In addition discarded packaging may retain or hold moisture and can harbor insects.

Composting

Probably the greatest drawback today of the composting process is that it has been viewed as a potential money-maker: wastes enter at one end and a valuable product comes out at the other end; and as the product is sold, a profit is made. Markets for compost have *not* materialized. Consequently, many facilities built with overly optimistic profit expectations have closed down, and it has often been concluded that the composting process is unsuitable to U.S. practice.

In actuality, of course, it costs about the same to perform composting as it does to incinerate. If incinerator operators were expected to sell heat, salvaged materials, and ash residue at sufficiently high prices to cover incineration costs, incineration would be no more economical than composting. For this reason, it is well to present composting as its wiser proponents now see it, i.e., in a neutral light—as a *disposal process* rather than as a *waste industry* which has failed to live up to its earlier promotional promises.

The composting process is best suited to the disposal of organic matter. Waste materials are converted by biodegradation into inert organic materials useful for soil conditioning. The first consideration to be applied to a material slated for processing by the composting route is whether or not it degrades by bacterial action; second, an indication of whether it can be handled in the process, either as a desirable or undesirable component.

Some mention has already been made about degradability earlier in the discussion of sanitary landfill. When evaluating sanitary landfill, we considered chemical oxidation as a form of degradation, particularly the rusting of steel cans. In composting, this kind of degradation is not considered; and, consequently, only three of the six major packaging materials categories can be said to be compostable: paper, wood, and textiles. No meaningful distinctions were discovered between the overall degradability characteristics of these major categories, although some differences between various subcategories were noted. For example, greater resistance was assigned to relatively thick materials and to paper or paperboard which is coated by nondegradable materials. Their greater resistance traces to the need to reduce such materials to small bits which are accessible to bacterial action.

Glass, metals, and plastics will not degrade in composting operations because they cannot be attacked and decomposed by bacteria. Glass usually presents no difficulty because it can be pulverized and left in the compost like sand or gravel; but it is not viewed with favor by European compost users who have long-term experience with such a product. Neither metals nor plastics are tolerable as components of compost, so they must always be removed.

Certain types of packaging materials, which are undesirable as compost components, can be removed with ease from the process stream. Others stay in the stream obstinately and call for a great deal of removal effort. Because these differences in ease of removability actually affect operating costs in composting, we made appropriate allowances in assessing the resistance of various materials which do not actually find their way into compost as an end product.

On this basis, plastics have relatively high resistance to composting. In the words of W. A. C. Weststrate, Managing Director of V. A. M., the Dutch Composting Corporation: "This substance cannot be pulverized and cannot (or only partly) be removed by means of ballistic separation. As a result of this, part of the plastic remains in the compost, which is a serious drawback. It spoils the outward appearance and sometimes causes trouble . . . with the finer tillage work."[4]

In comparison with plastics, metals can be removed with relative ease thanks to their magnetic properties or, in case of aluminum containers, because they are heavy enough to respond well to ballistic separation methods. Aluminum foils resist separation because they can neither be removed magnetically nor thrown out ballistically.

Viewed overall, packaging materials will be both more and less suitable for composting by 1976. There will be much more paper in a ton of packaging materials, thus increasing the degradable proportion of total waste. On the other hand, there will be much more plastic film, the material which is least suitable to the composting process—both in terms of biochemical resistance and also physical configuration. Moreover, an increasing volume of paper packaging will be coated with plastic materials which are relatively undegradable.

Salvage, Reuse, and Conversion

Any discussion of the salvage, reuse, and conversion of packaging materials should be prefaced with the statement that only an extremely small percentage of packaging materials are ever salvaged, reused, or converted after they enter the residential waste stream. Salvage is *not* an accepted and practical disposal route; at best it is a minor adjunct to other waste disposal operations.

The salvage industry in the United States is a large and active one. It has gross sales exceeding $3 billion annually and at least 2,300 major participating companies. But this industry is based not on municipal waste operations but upon commercial and industrial wastes which are collected in relatively clean and well-segregated form. Packaging wastes from residential trash barrels are poor candidates for salvage because of their mixed contents.

The major cost of salvage lies in collection and separation of the materials. This is why the salvage industry favors sources of supply where wastes are available in clean and homogeneous batches, and it explains why the heterogeneous mass of soiled municipal wastes is unattractive to the salvage industry.

Salvage of municipal wastes is carried out on a very minor scale at landfills, incinerators, and in some composting plants. All of the salvage plants which were operated in the U.S. during and following World War II have been closed down.

A salvage operation typically consists of a system of moving belts which receives the waste materials and conveys them to various stations which employ mechanical means or labor to separate the items according to composition, color, magnetic properties, etc. The separated materials are then bundled or packaged. Material which continues to the end of the conveyor is disposed of by incineration, composting, or landfilling.

The fundamental movement in the salvage industry is toward materials of greater "purity." All sources consulted in this investigation were emphatic on this subject. The buyer of secondary materials is becoming more and more concerned with the quality and uniformity of the materials he is buying. Producers of steel, paper, and glass are all using less scrap per ton of product than heretofore. This is partly because of changes in processing, but also because reclaimed materials offer little or no price advantage—and often involve serious processing difficulties—compared with virgin materials.

Reclaim and re-use of packaging materials are made still more difficult by the multiplication of packaging types, the increasing variety of combinations of dissimilar packaging materials (plastics and paper, metals and paper, metals and plastics, etc.) in extremely difficult-to-segregate laminations, the development of many new kinds of material coatings and inks, and the proliferation of new families of materials with unique performance characteristics.

The trend of growing complexity is in direct conflict with the trend of greater user insistence upon purity because separation is becoming more costly and the chances of "contaminating" one waste category with materials from some other category are increasing. The higher handling costs associated with the present packaging material mix and the depressed condition of waste markets due to declining consumption of waste per unit of new production are combining to inhibit salvage as a practical disposal method.

Steel salvage: Of the 6.79 million tons of steel which appear in packaging every year, virtually nothing is recovered. In 1962, for example, salvage operations accounted for the return of 850,000 tons of tin-coated metal to the steel industry. The overwhelming bulk of this salvaged material came from detinneries, which rely for their materials on clean clippings from can production plants. Very little of the total came from the recovery of used steel cans.

The basic reason for the small place packaging metal wastes have in scrap markets is because of the tin coating on cans which represent the bulk of the metal in packaging wastes. The tin coating itself is a minor part of the can representing only about one-half of one percent of the total weight of a typical can. This amount of tin, however, suffices "to make a tin can the lowest form of metallurgical life except perhaps a window sash weight" in the words of a longtime observer of salvage markets.[5]

Tin is an unacceptable component in steel. It enters steel as a residual alloy and forms hard spots and creates difficulties in the rolling process. Minute quantities of tin impurities are tolerable; but the volume of tin represented by tin cans is too high. Consequently, scrap iron containing tin cans is typically rejected by the steel industry. It is not an exaggeration to say that scrap bundles containing tin cans (No. 3 bundles and incinerator bundles) represent commodities on the periphery of the scrap market. Prices for these grades of scrap are not quoted as a rule in the industry's weekly trade publication, the *Waste Trade Journal.*

With no markets in the steel industry, scrap tin cans are salable only to manufacturers of cheap metallic goods such as window sash weights and other ballast. Tin cans *are not* normally routed to detinneries. The situation is summed up by William S. Story of the Institute of Scrap Iron and Steel as follows:

> "There are detinning operations around the country, and successful ones, but these work solely with new tins and tin can clips from tin can producers. They do not operate on tin can waste because of the economics of cleaning the material."[6]

Detinning of used tin cans was practiced during World War II when homemakers were encouraged to clean and flatten the cans. Processing plants, obviously, relied on the cooperation of the consumer to accomplish the costly cleaning process.

Another outlet for tin cans is in copper manufacturing where tin-coated iron can be used to precipitate copper. "Precipitation iron," as this material is called, must be clean, burned, and shredded. Markets for precipitation iron are generally in the Southwest. High freight charges associated with the light density shredded metal effectively prohibit the transport of such a material over long distances from population centers located to the east and north.

We can conclude that tin cans are recoverable and reusable only at a cost which generally eliminates them from consideration in the scrap market. In order to make steel cans more eligible for reuse as scrap, the basic material composition must be changed to eliminate the tin coating and the lead solder. Without these contaminants, steel cans could be recycled with relative ease. The switch to a tin free steel has now begun and is forecast to progress significantly in the next few years.

Aluminum Salvage: In spite of considerable public interest—and publicity—surrounding various programs to salvage and recycle aluminum packaging materials the conclusion of our study is not hopeful in this regard. It may be stated simply:

(1) Markets do exist for scrap aluminum packaging materials, but

(2) The prices paid for aluminum scrap are too low to maintain economically self-sustaining salvage programs.

In other words, apparently successful programs currently being conducted depend upon some form of public subsidy, usually in the form of free collection labor. Youth groups such as the Boy Scouts often participate in these programs.

Aluminum scrap today sells between 12.5 and 13 cents per pound. Processors cannot afford to separate waste aluminum cans at this price, so this chore must be accomplished by obtaining the voluntary cooperation of housewives. By the most optimistic estimates of one aluminum producer, such voluntary effort could result in the recovery of 5 percent of the aluminum packaging waste, which would mean that by 1976 total packaging waste would be reduced by 50,000 tons—less than 0.001 percent. This highly optimistic estimate is not shared by the MRI research team.

Aluminum packaging salvage is not expected to reduce seriously the load on waste disposal agencies—or to save much of this vital national resource—until the price of scrap aluminum rises sufficiently to permit profitable commercial operations.

Before aluminum packaging waste is regarded as a good source of supply by the secondary aluminum industry, it will have to be collected in much larger quantities. U.S. Reduction Company, which sells more than $5 million worth of secondary aluminum a year, estimates that a city would have to supply between 100,000 and 1 million pounds of aluminum every month before it would be considered a good source of supply. Contrast this with the 4,000 plus pounds of aluminum packaging materials collected every month during the first three months of a recent collection campaign in Miami—a campaign accompanied by a good deal of publicity and a relatively high price paid for the waste material (one cent for two cans).

By 1976, the situation should be slightly better for two reasons: first, the amount of aluminum in the refuse will have increased, thereby increasing the salvage output per ton of unseparated waste; and second, the magnesium content of aluminum packaging materials is expected to decrease. Aluminum containing low magnesium is more valuable to the secondary aluminum processor.

At the present time, however, aluminum salvage programs are not economically self-sustaining. They are heavily subsidized, either by the public or the corporations involved.

Paper Salvage: In 1966, more than 21 percent of the fiber used in paper and paperboard production (10.2 million of 47.7 million tons) came from waste paper. Paper packaging materials, in the form of old corrugated boxes, represented 2.5 million tons of the total. With the exception of old corrugated boxes, paper packaging materials were not recovered.

Waste paper has been declining in importance in papermaking since World War II. In 1946, waste paper supplied 35 percent of the fiber requirements for paper and board; in 1956, slightly over 26 percent; in 1966, 21 percent; and if the past trend continues, one observer places the recovery rate in 1980 at 17.5 percent.[7]

The decline in these percentage figures should not be construed to mean that the *tonnage* of reused waste paper has also been decreasing. Actually, it has increased from 7.3 million tons in 1946 to 8.8 million tons in 1956 and to 10.2 million tons in 1966. The declining percentage simply means that the re-use of waste paper is not growing as rapidly as the use of other fibers such as wood pulp, rags, cane fiber and straw (Table 78).

Reasons for this decline include (1) "contamination" of paper by plastics, clay coatings, inks, laminants, and adhesives; (2) increased costs of waste paper collection as a result of suburban sprawl; (3) technological advances in wood pulping, computer control of the process, etc.—which result in higher fiber yields from virgin materials; and (4) integration and expansion moves within the paper and paperboard industries which have resulted in additions of virgin pulping capacity.

Within the context of this overall situation, the outlook for the salvage of paper-based packaging material wastes is not encouraging. As noted earlier, three-fourths of the waste paper recycled to the paper industry is derived from waste sources *other* than packaging wastes. Virtually none of this recycled paper—with the exception of old newspapers—comes from residential sources, even though these sources generate a large proportion of packaging wastes as a whole.

The only paper packaging material which plays a significant role in the paper salvage trade is old corrugated boxes. An estimated 2.5 million tons of such boxes were collected and reused in 1966, amounting to 20 percent of the 12.5 million tons of container board produced that year.

The other paper packaging materials are ignored by salvage operators because waste paper dealers (usually called "paperstock" dealers) can profitably pack and grade only those materials which have been separated at the source and labeled as to contaminants. The prices paid for waste paper are too low to cover the cost of sorting heterogeneous masses and decontaminating the paper portions.

Old corrugated boxes are often profitably collected from retail stores because the volume is substantial and the boxes are clean and easily separated for salvage and reuse. Old newspapers are sometimes collected under the auspices of not-for-profit or charitable organizations (schools, Boy Scouts, churches, etc.). No. 1 Mixed Paper, one of two paper bale categories in which paper packaging wastes could conceivably be graded,* is derived almost exclusively from the waste paper baskets of large administrative centers (office buildings, schools, etc.). No. 1 Mixed Paper is a

---

*The other grade is No. 2 Mixed, a grade in which all papers are acceptable; since No. 1 Mixed is presently in a depressed stage due to oversupply, with the price per ton at $1 in some markets, no prices are quoted in the trade for No. 2 Mixed, which is worthless.

TABLE 78.—*Consumption of fibrous materials in paper and board mills*

In tons

Year	Wood pulp	Paper stock	Rags	Other	Total
1904	2,018,764	588,543	294,552	411,614	3,313,473
1909	2,826,591	983,882	357,470	420,217	4,588,160
1914	3,490,123	1,509,981	361,667	429,009	5,790,780
1919	4,019,696	1,854,386	277,849	470,393	6,622,324
1929	6,289,318	3,841,942	739,422	704,063	11,574,745
1935	6,442,178	3,587,390	501,589	467,360	10,998,517
1939	8,650,423	4,366,357	468,287	692,315	14,177,282
1940	9,781,739	4,667,502	402,600	640,967	15,492,808
1941	11,363,600	6,075,129	529,967	887,581	18,856,286
1942	11,038,020	4,494,959	480,614	844,337	17,857,930
1943	10,635,320	6,367,854	425,910	770,358	18,199,442
1944	10,502,204	6,859,332	427,837	957,389	18,746,762
1945	10,825,412	6,799,683	414,083	929,453	18,968,631
1946	12,092,093	7,278,097	402,506	979,755	20,752,451
1947	13,252,924	8,009,052	462,388	1,063,161	22,787,525
1948	14,374,586	7,584,501	415,668	1,036,044	23,410,799
1949	13,635,957	6,599,606	381,915	833,174	21,450,652
1950	16,508,905	7,956,036	441,894	997,444	25,904,279
1951	17,736,970	9,070,554	387,843	1,069,159	28,264,526
1952	17,286,030	7,881,193	324,560	886,556	26,378,339
1953	18,683,543	8,530,662	325,154	929,461	28,468,820
1954	18,989,159	7,856,637	316,737	882,955	28,045,488
1955	21,453,766	9,040,768	340,353	1,000,060	31,834,947
1956	22,998,380	8,836,449	298,259	1,253,070	33,386,158
1957	22,459,420	8,493,109	1,015,475		32,058,004
1958	22,483,118	8,670,824	1,003,335		32,157,277
1959	25,155,362	9,414,153	979,940		35,548,972
1960	25,700,031	9,031,614	970,940		35,702,585
1961	26,682,863	9,017,749	894,257		36,594,869
1962	28,598,333	9,074,815	962,918		38,636,066
1963	30,220,000	9,613,000	1,285,000		41,118,000
1964	32,088,000	9,843,000	928,000		42,859,000
1965	33,790,000	10,297,000	878,000		44,965,000
1966	36,444,000	10,159,000	1,054,000		47,657,000

Source: American Paper and Pulp Association. *Statistics of Paper, 1964.* August 1964. p. 21. *Paperboard Packaging,* 52(8): 36, Aug. 1967.

sorted product, with the paperstock dealer performing the sorting operation.

These three categories of paperstock—corrugated, newspaper, and No. 1 Mixed—account for 85 percent of all recovered paper. The remaining 15 percent is made up of highly uniform wastes from commercial operations (converters, printers, paper mills, etc.). Thus with the exception of old corrugated boxes, paper packaging materials do not play a role in the paper stock industry.

No. 1 Mixed Paper has been declining in price recently because of oversupply, and also because of rising degrees of contamination associated with office building wastes. Such waste contains a large amount of excellent fiber which is desirable in paper stock, but it is becoming increasingly diluted by plastic cups, photocopy paper, lunch scraps, typewriter ribbons, carbon paper, and claycoated papers, thus making it much more costly to sort. If it is not properly sorted, it brings much lower prices.

Recent prices paid by dealers for No. 1 Mixed Paper and Old Corrugated Boxes are shown in Table 79. Prices paid for two other waste paper categories, both subdivisions of New Double Kraft Lined Corrugated Clippings, are also shown. New Corrugated Clippings are derived from box manufacturing wastes. It is instructive to note that in this instance, the highly uniform clipping wastes, low in contaminants, command a con-

TABLE 79.—*Selected paperstock price ranges: 1966 to 1967* [a]

In dollars per ton

Month and year	New York City				Chicago			
	No. 1 mixed paper	Old corrugated boxes	Semichem 0.009 medium double lined kraft corrugated clippings	Mixed 0.009 medium double lined kraft corrugated clippings	No. 1 mixed paper	Old corrugated boxes	Semichem 0.009 medium double lined kraft corrugated clippings	Mixed 0.009 medium double lined kraft corrugated clippings
October 1966	10/12	23/25	35/45	30/40	6	24/26	35/45	30/40
November 1966	10	20/21	30/35	25/30	6	18/22	33/35	25/30
December 1966	4/10	19/20	25/30	20/25	6	16/20	25/30	20/25
January 1967	4/6	14/18	25/30	20/25	6	16/18	25/30	20/25
February 1967	4/6	14/18	25/30	20/25	6	12/18	25/30	20/25
March 1967	3/6	15/18	....	....	6	12/18	....	....
April 1967	1/4	15/18	....	....	6	12/16	....	....
May 1967	1/4	15	25/30	20/25	6	12/16	25/30	20/25
June 1967	1/4	15	22.50/30	17.50/25	6	12/16	25/30	20/25
July 1967	1/4	15	22.50/30	17.50/25	6	12/16	25/30	20/25
August 1967	1/4	15	25/30	20/25	6	12/16	25/30	20/25
September 1967	1/4	15	....	....	6	12/16	....	....

[a] Mill prices F.O.B. cars or trucks, in bales—500 lb. minimum.

Source: *Paperboard Packaging*, 51(11), November 1966 through 52(10), October 1967.

siderably higher price than even the relatively uncontaminated corrugated box and mixed paper grades.

It is the consensus of knowledgeable observers in this field that effective salvage operations necessarily call for the separation of the paper wastes into suitable grades *at the generation source*, with the possible exception of newspapers and corrugated boxes, which are sometimes separated following waste collections at the disposal plant. Once paper materials have entered a compactor truck, they are literally worthless by reason of contamination with garbage, moisture, and other organic materials. Certain types of paper material, especially plastic coated items such as milk cartons, would not be acceptable for recycling even if segregated at the source.

The costs of processing waste paper are, on the whole, considerably higher than disposal costs. To sort and bale No. 1 Mixed Paper involves an estimated minimum cost of $3 to $4 per ton. The cost of separating paper from the mix of other residential and commercial/industrial refuse is estimated to be considerably higher. No. 1 Mixed Paper, as delivered to the sorting concern, is already a relatively homogeneous material.

To be economically viable, a salvage operation as practiced by the operator of a disposal facility must at least break even. This would imply that disposing of a ton of paper by the salvage route would have to cost no more than disposal by some other means. Disposal costs range anywhere from $1 to more than $10 per ton of waste depending on the process used. It is evident that salvage of paper in conjunction with dumping operations (the least costly) would not be economically feasible, whereas it may prove attractive on a limited basis in processes where the unit costs of disposal are considerably higher (come posting and incineration). However, in view of the extremely low prices paid for the less desirable paper stock grades, only corrugated boxes among packaging materials appear to offer an economically desirable salvage opportunity.

Since only a portion of paper wastes is presently salvaged, the fact that the proportion of waste paper to virgin fibres is expected to decline further in papermaking, and the fact that much more, rather than less, contamination of the waste paper appears to be the trend, it is our conclusion that salvaging will be an even less attractive method of disposing of paper-based packaging wastes in 1976 than in 1966—unless salvaging can somehow be made more economically attractive to its participants.

Glass Salvage: Glass salvage must be viewed from two separate vantage points. Returnable bottles are eminently salvable, and the collection and recycle systems for handling this type of package are well developed and operative. On the other hand, the theoretically salvable nonreturnable glass containers do not appear to play a very significant role in glass making.

Returnable glass containers (beer, soft drink, and milk) represent a small percentage of total glass packaging production. On a unit basis, in 1966, 9.1 percent or 2.7 billion units of a total of 29.4 billion units were of the returnable type. The rise of one-way beer and soft drink containers will result in an absolute and relative decline in the number of units of this type to be produced by 1976. In that year, 1.7 billion units of a total glass container production of 45.7 billion units will be returnable, or 3.8 percent of total units. Unfortunately, the most salvable of all glass containers will actually diminish in importance between now and 1976.

Clean, sorted, crushed glass known to the trade as "cullet"—is a recognized waste-glass commodity which is used in glass making to speed up the melting of virgin silica. Cullet may be obtained from two sources: scrap dealers who specialize in collecting, sorting, and cleaning glass wastes, and from glass plant wastes. Cullet represents between 15 and 30 percent of the input materials used in glass making.

Fairly accurate data on glass salvage, particularly cullet usage in glass manufacturing, should be emerging soon from a study presently under way under the auspices of the Glass Container Manufacturers Institute. At this time, little in the way of applicable survey data is available, but certain facts appear to be clear.

The major portion of the cullet used in glass making at present is derived from in-house process waste. Scrap dealers who sell cullet to glass manufacturing plants obtain their supplies from various commercial or industrial operations where relatively uncontaminated and homogeneous material is available in quantity—bottling plants, dairies, breweries, etc. Glass is segregated at very few waste processing facilities.

One reason why glass is not salvaged at dumps, landfills, incinerators, or at various waste transfer stations is that the costs of separating and cleaning cullet have increased substantially. This is reflected in cullet prices, which have risen from $8 to $9 per ton in 1959 to $15 per ton in 1967. In some localities, for example in the Chicago area, scarcity of low-cost labor has effectively priced cullet out of a market. A 1967 private study of glass salvage in the Chicago area concluded that cullet could not be profitably processed there even at a price of $30 per ton.

Sorting and cleaning costs may be placed in focus by considering that about 3,600 bottles will yield a ton of cullet (Table 80). Many times this number of units would have to be handled to obtain a ton of cullet of a particular grade (flint cullet, amber cullet, etc.). Once the bottles are sorted, they must be crushed. The crushed material, in turn, must be washed, dried, and packaged. Transportation costs have to be added to the selling price to obtain true cost to the manufacturer.

In glass, as in virtually all other material groupings, impurities in and accompanying the base material are increasing. One instance is the twist-off cap which leaves a slender ring of metal around the neck of a bottle. Since the metal is aluminum, this impurity cannot be removed from crushed cullet by magnetic means; nor will it wash out. Consequently, bottles with twist-off caps must either be eliminated from cullet stock at the outset, or expensive hand removal of the aluminum from the crushed material must be accomplished.

TABLE 80.—*Number of glass containers required to make one ton of cullet*

Type of container	1966 avg. weight/ gross (lb)	Weight/ unit (lb)	Unit/ ton [a]
Soft drink returnable	141.2	0.981	2,039
Soft drink nonreturnable	88.6	.615	3,252
Beer returnable	85.5	.594	3,367
Beer nonreturnable	68.1	.473	4,228
Liquor	125.5	.872	2,294
Wine	155.0	1.076	1,859
General line narrow neck (food, drug, chemical, toiletry)	68.4	.475	4,210
General line wide mouth (food, drug, chemical, toiletry)	63.2	.439	4,556
Average—all glass containers	79.8	.554	3,610

[a] The fewer units per ton represent lower handling requirements for salvage purposes.

Source: Glass Container Manufacturers Institute, Inc., unpublished data. Midwest Research Institute.

Label stock is relatively easy to remove by sufficient soaking and washing of the cullet. However, cullet dealers, understandably enough, prefer to process glass wastes which do not carry labels; in that way, the processing time is shortened.

The number of colors which can be obtained in glass making is growing as a result of advances in glass technology. Competitive forces at work in the marketplace favor recognition of product by introducing novel color-shape combinations. The effect of color multiplication on salvage is to render more and more of the waste glass unsuitable for use in grades other than brown bottles—primarily beer containers, medicinal bottles and jars, and chemicals—which represent a low percentage (under 20 percent) of total glass.

Plastics Salvage: The salvage of plastics from residential-commercial refuse is not practiced at present. Plastics wastes are collected by scrap dealers from extruders, converters, and molders and fabricators. Among these suppliers, extruders rank highest in the eyes of the scrap dealer because the material obtained is uniform and clean. Molders and fabricators supply the smallest percentage of plastics that enter reuse channels owing to the relatively high degree of contamination of the materials. Converters are not considered a good source since the waste materials are frequently contaminated by printing inks.

There appears to be no practical way in which plastics can be separated from refuse, sorted by grade, cleaned, and processed at a price that would even remotely approach prices currently commanded by plastic trim and process wastes. Most prices range from $25/ton for mixed vinyl to $180/ton for single color cellulose acetate. In late 1967, polyethylene, which accounts for the bulk of packaging plastics, was virtually worthless as scrap. Earlier in 1967, polyethylene wastes from printing plants, free of ink, sold for a low of $25/ton and a high of $40/ton.

Some idea of the complexity of activities involved in reclaiming and reprocessing of plastics wastes is given in Charles Lipsett's book, *Industrial Wastes and Salvage*. Summarizing Mr. Lipsett's account, six steps are required to process a nonfilm plastic waste material (obtained from an *industrial source*) into a salable product.

(1) Scrap is sorted—by type of material and by color; impurities are removed by hand.

(2) Scrap is reduced to small pieces by guillotine or saw.

(3) Pieces are ground; ferrous metals are removed by magnetic means; special techniques are used to eliminate nonferrous metals.

(4) The resulting powder is blended for colors. Depending on the operation, pigments and plasticizers may be added.

(5) Blended powder is heated to between 400 and 500 F to set the color; cooling and pelletizing follows.

(6) The colored plastic is pelletized and packaged.[8]

The relatively small percentage of plastics in packaging waste, the high vulnerability of plastic materials to contamination, and the virtually indissoluble unions in which they often appear (as coatings, laminations)—all of these factors indicate that the salvaging of plastic packaging material wastes will be physically and economically impracticable between now and 1976 unless normally operating market forces are modified in some manner.

Other Salvage: The two remaining packaging material categories, wood and textiles, are used predominantly in industrial packaging applications. Wooden pallets and boxes, tight and slack cooperage and textile bags are reusable. Wooden containers are far more repairable than other package types which make their continued use possible, with some inputs of labor, even after they are damaged. These packages, however, enter the waste stream in approximately the same volume as annual production; they are discarded once it is no longer practical to repair them. Textile sacks can be sold to scrap dealers once they have outlived their usefulness; they enter secondary fiber reuse channels.

Summary: With the exception of corrugated containers, packaging materials are not economically salvable because of contamination problems and the high costs of separation and sorting. Most scrap industries have evolved, through the years, around industrial and commercial waste sources from which relatively high purity materials can be obtained in quantity. We have found no indications of technological or market developments which might be expected to change this situation significantly before 1976.

ANALYSIS OF RESISTANCE TO PROCESSING*

Approach to the Analysis

Any given tonnage of discarded packaging materials is likely to pass through at least five broadly defined disposal processes. Given 100 pounds of steel cans, for instance, 14 pounds would pass through an incinerator, five would end up in a landfill, 77.5 pounds would be dumped, three salvaged, and half a pound would pass through a compost plant.

It follows from this that the disposability of a tin can has to be evaluated from at least five points of view: from those of the incinerator plant, open dump, landfill, compost plant, and salvage plant operators. Depending on the suitability criteria associated with each process, a metal can looks very good or very bad. Furthermore, if the can has an excellent suitability rating in a process which handles a bulk of the waste, its overall suitability would be greater than in a case where it shows low suitability in the dominant process.

Our aim in this analysis was to create a measure or index value which would establish the relative disposability of a material in each process in such a manner that the values would be comparable. This clearly called for a numerical system. We selected a scale extending from 100 to 500, whereby 100 stands for excellent, 500 for unsatisfactory. In actual practice, each material was rated for each disposal process on this scale. Each material, consequently, received five different values, between 100 and 500. How values were actually assigned is explained below.

In the course of developing this rating technique, our aim was to arrive at numerical values that would express relative measures of *technical resistance* of materials to processing. Once the values were established for individual packaging materials, they could be applied in proportion to their 1966 consumption quantities to develop an index of resistance for packaging materials as a whole. Then, by recalculating the index for the packaging materials mix expected in 1976 and adjusting it for expected shifts in future emphasis among the different disposal processes, one may obtain a fairly accurate indication of how much total resistance to disposal will increase or decrease by 1976.

How Resistance Values Were Assigned

Analysis of the technical characteristics of each disposal process (discussed earlier) disclosed those physical and chemical properties of waste which were most suitable for each disposal method. These are summarized in Table 81. The process analysis also revealed the relative importance of each property. This relative importance was then expressed numerically as portions of unity (1.00) for each process.

TABLE 81.—*Suitable material characteristics*

In this process—	These material characteristics are the most suitable	These characteristics have the following relative importance
Sanitary landfill	High natural density	0.05
	Compactibility of the material	.80
	Degradability of the material	.15
Incineration	Combustibility of the material	.75
	Low inert solids residue	.15
	High BTU value	.04
	Low sulfur content	.01
	Little or no potential to cause damage to the incineration equipment	.05
Composting	Degradability	.80
	Suitability	.20
Salvage, reuse, conversion	Easily separable	.25
	Existence of market for the commodity	.75

Source: Midwest Research Institute.

A discussion of sanitary landfilling will illustrate the nature of this analysis. In this process, materials are deposited in natural hollows or depressions or in manmade excavations; they are compacted by heavy machinery; and they are covered daily by inert fill materials. Compaction serves to reduce the voids between wastes, thus preventing or minimizing the formation of hollows where rodents and insects might breed. Compaction also serves to maximize the quantity of refuse which can be deposited at a given landfill site and thus extend its capacity and period of usefullness. Covering of the fill on a daily basis ensures sanitary conditions, eliminates odors and unsightliness, and prevents infestation of the waste by rodents and insects from the surface.

---

*To simplify analysis, miscellaneous packaging categories are not included in this section.

One of the more significant aspects of landfilling is that it is frequently a land reclamation process. Useless gullies and depressions are filled up—not with expensive fill material but with waste. Therein lies the attractiveness of the process and the justification for operating landfills near residential and industrial areas.

Suitable landfill sites are rarely available near population centers. And as sites are progressively located farther from cities, hauling costs increase substantially. For this reason, maximum exploitation of good sites becomes economically desirable, and there is growing need to compact the fill materials as densely as possible.

Needless to say, materials with a high natural density and good compactibility offer less disposability resistance than lightweight materials with a good deal of elasticity and spring-back. Package density, however, is relative to configuration—whereby an uncrushed metal can may take up far more space due to its shape than an equal weight of paper. For this reason, compactibility of the waste material is the most important single criterion in landfill operations: the best possible material is one which is made of a heavy material, can be compacted with ease, and will retain its compacted shape when pressure is released.

Degradability is desirable for another reason: most landfills are ultimately destined to become sites for urban redevelopment—parks, residential areas, golf courses, industrial sites, etc. When redevelopment work begins, it is desirable that excavators find as few of the remains of disposal operations and as homogeneous a soil as possible. For such purposes, landfill sites which received readily degradable organic wastes would be the most ideal. If inorganic packaging wastes must also be stored, a site which received packages that would lose their characteristic shape over time would be more suitable for redevelopment than a site which received large quantities of packaging that retain their shape for decades. Since, however, ultimate use of the site is usually a secondary consideration, degradability is not given as high a value in our system as compactibility.

Much the same reasoning was used to determine the relative suitability of packaging material characteristics for disposal by other processes.

It will be noted that Table 81 does not show open dumping as a disposal technique, and this omission calls for some comment.

It is impossible to determine how much packaging waste is dumped in clearly authorized dumps and how much is simply discarded by people along streets, highways, lakes, rivers, parks, etc. Large numbers of bottles and cans are thrown into water bodies where they eventually sink out of sight—and out of mind. Containers, wrappers, and other materials tossed from car windows remain in view. Many trash materials are discarded in unauthorized dumps which seem to invite further dumping. As a consequence, much of the waste tonnage assigned to open dumping actually ends up in other than authorized locations.

This situation has dictated our approach to the assignment of resistance values to materials in open dumping. Not being, strictly speaking, a disposal process so much as a manner of storing wastes in a more or less controlled manner, materials which are disposed of in open dumps are not processed. Consequently, they do not exhibit resistance to processing as such. Since the ratings as used here are based on resistance to processing, all materials thought to end up in dumps are given the lowest index of resistance available. No attempt to evaluate the characteristics of this disposal mode was made, with the result that open dumping does not show up in Table 81. The low resistance ranking of materials which are dumped should in no case be construed as an endorsement of this disposal technique.

Having established the suitability of various material characteristics in each process and having assigned each a relative numerical value, the actual material ratings could be developed. The scale of numerical values ranged from 100 to 500 as follows:

100—Excellent
200—Good
300—Fair
400—Poor
500—Unsatisfactory

Each individual packaging material was assigned one of these five numbers. In order to apply the rating system consistently, careful definitions were developed for each material characteristic in each process. These definitions are shown as Tables 82 through 85.

TABLE 82.—*Rating definitions of incineration*

Rating	Rating code	Burning rate	Inert solids residue after incineration weight in percent	BTU value 1,000 BTU's per pound	Sulfur content weight and percent	Potential damage to equipment from the material
Excellent	(100)	Very high	2 to 5	12 and above	0.01 to 0.05	None.
Good	(200)	High	5 to 10	10 to 12	0.06 to 0.10	None when incinerator is operated properly.
Fair	(300)	Slow	10 to 20	8 to 10	0.11 to 0.15	Can sometimes disturb system operations.
Poor	(400)	Self-extinguishing.	20 to 50	6 to 8	0.16 to 0.20	Seriously disturbs system operations.
Unsatisfactory	(500)	Nil	50 and above	Below 6	0.20 and above	Damage can be considerable.

Source: Midwest Research Institute.

TABLE 83.—*Rating definitions of sanitary landfill*

Rating	Rating code	Natural density of the material (pounds/cubic foot)	Compactibility	Degradability
Excellent	(100)	100 and above	Deforms or crushes easily under pressure and retains compacted form after pressure is released.	Item will eventually degrade and disintegrade in soil by bacterial action.
Good	(200)	71 to 100	Deforms easily but springs back when pressure is released.	Item is partially degradable.
Fair	(300)	51 to 70	Deforms with difficulty	Item will decompose by chemical action.
Poor	(400)	31 to 50	Deforms but requires special handling in landfill operations.	Highly resistant to both bacterial and chemical action in the soil.
Unsatisfactory	(500)	30 or less	Not effectively compactible in conventional landfill operations.	Virtually indestructible; will not degrade.

Source: Midwest Research Institute.

TABLE 84.—*Rating definitions of composting*

Rating	Rating code	Degradability	Handling suitability
Excellent	(100)	Degrades quickly	Suitable.
Good	(200)	Degrades slowly	Suitable, but requires pulverization or special equipment for reduction.
Fair	(300)	Degrades partially	Unsuitable, but can be removed without difficulty by mechanical means.
Poor	(400)	Does not degrade but may be left in the compost.	Unsuitable but can be removed by manual means.
Unsatisfactory	(500)	Does not degrade and is an undesirable component of compost.	Unsuitable and difficult to remove by any means.

Source: Midwest Research Institute.

TABLE 85.—*Rating definitions of salvage, reuse, and conversion*

Rating	Rating code	Separability	Market for commodity
Excellent	(100)	Separation is possible by mechanical means.	Market for the commodity exists and may be supplied with little or no preprocessing of the commodity.
Good	(200)	Mechanical separation is possible but must be supplemented by hand sorting.	Market exists for the commodity, but seller must sort commodity into grades or types before it is salable.
Fair	(300)	Separation is possible only by manual means; minimum sorting required.	Market exists, but seller must process the commodity by shredding, cleaning, renovating, etc.
Poor	(400)	Separation is possible only by manual means; considerable sorting is required.	Market does not exist for the commodity but may be a possibility via chemical conversion or extensive processing.
Unsatisfactory	(500)	Not practically separable	Market does not exist for the commodity and is unlikely to develop.

Source: Midwest Research Institute.

Basically, these definitions were used as a guide for classifying packaging materials on the basis of either a numerically measurable or clearly spelled out characteristic.* Thus, for instance, under compactibility, a steel can is considered "excellent" because it deforms easily and permanently, and it has relatively high density after compaction; containerboard is considered "good" because, although it deforms easily, it has relatively low density after compaction; plastic bleach bottles are "fair" because they spring back resiliently after compaction; bulky items like steel drums are "poor" because, although compactible, they need special handling; metal cylinders are not effectively compactible, so they are rated "unsatisfactory."

How the Index Was Calculated

In this analysis, 40 separate material subcategories were rated: 15 paper items, 10 metal, five glass container types, five wood categories, four plastic, and one textile. These were rated in 12 areas: two for sanitary landfill, five for incineration, two for composting, and two for salvage (Table 81). Altogether, then, 480 separate rating judgments were made. How these separate ratings were used to determine a single average value for all packaging materials in all processes will now be outlined. Metals will be used to illustrate the procedure.

Step 1: Rating

Materials were first rated in accordance with the criteria laid down in the rating definitions. The rating work sheet for metals is shown as Table 86. Note the weight (relative importance) factors assigned to each subcategory under each process.

Step 2: Consolidation

Using the values shown in Table 86 and the weighting factors assigned to each subcategory, a single composite value was calculated for each material under each process. These composite values were then entered on Table 87.

Steel cans, in sanitary landfilling for example, are rated 100 for density, 100 for compactibility, and 300 for degradability. Weighting these by the relative importance factors assigned to each of these process subcategories yields the following:

$$\begin{aligned} 100\times0.05 &= 5 \\ 100\times0.80 &= 80 \\ 300\times0.15 &= 45 \\ \text{Total} &= 130 \end{aligned}$$

Thus, the resistance of steel cans in sanitary landfilling is 130, falling between excellent and good. This value is inserted in the "Value" column under Landfill on Table 87. Identical operations were performed for each material and for each process.

Step 3: Weighting by Market Share Within Categories

Steel cans are an important part, but by no means the only part, of metals in packaging. On a tonnage basis, steel cans in 1966 represented 72.3

---

*Some of the limitations of the definitions used are pointed out elsewhere; see pages 124 and 139.

TABLE 86.—*Disposability ratings: Metals*

Product	Sanitary landfill			Incineration					Composting		Salvage	
	Density 0.05	Compactibility 0.80	Degradability 0.15	Burning rate 0.75	Inert solids 0.15	Btu value 0.04	Sulfur content 0.01	Potential damage to equip 0.05	Degradability 0.80	Suitability 0.20	Separability 0.25	Market for the commodity 0.75
Steel cans	100	100	300	500	500	500	100	100	500	300	100	300
Aluminum cans and ends	100	100	400	500	500	500	100	100	500	300	400	200
Collapsible tubes	100	500	400	500	500	500	100	100	500	300	500	500
Rigid aluminum foil cont	100	100	400	500	500	500	100	100	500	400	400	200
Aluminum foil converted	100	100	400	500	500	500	100	100	500	400	400	400
Steel drums and pails	100	300	300	500	500	500	100	300	500	400	100	100
Metal strapping	100	400	300	500	500	500	100	300	500	400	100	100
Gas cylinders	100	500	300	500	500	500	100	500	500	400	100	500
Metal caps	100	100	300	500	500	500	100	100	500	300	500	500
Metal crowns	100	100	300	500	500	500	100	100	500	300	500	500

Source: Midwest Research Institute.

percent of total metals. In consequence of this, in order to arrive at an overall resistance value for *all* metal packaging materials in sanitary landfilling, for example, only a portion of the steel can resistance value can be counted or 130 × 0.723, which equals 94.0. Thus, steel cans in sanitary landfilling contribute 94.0 points toward some final value between 100 and 500 for all metals in sanitary landfilling.

Table 87 also shows how index numbers for all metal products in all processes were obtained. This operation was performed for all material groupings. The results are summarized in Table 88.

Step 4: Calculation of the Index

In 1966, paper and paperboard represented 54.75 percent of total packaging materials tonnage. Incineration of all kinds accounted for 14 percent of all waste disposed. Paper had a resistance value of 150 in incineration in that year. Consequently, in order to arrive at an overall resistance value for all packaging materials in all processes, only a portion of paper's resistance value in incineration can be counted toward the total for all materials. The portion is determined by multiplying paper's resistance value in incineration (150) times paper's share of total tonnage (54.75 percent) times incineration's share of total waste tonnage (14 percent). This results in the following calculation: 150×(0.5475×0.14)=11.5. In other words, that portion of paper which passed through incineration contributed 11.5 points toward a final figure, between 100 and 500, for packaging materials as a whole.

The same weighted adjustment technique was used for each material grouping in each process to establish a final index value for packaging mate-

TABLE 87.—*Disposability resistance calculation: Metals, 1966*

Product	Share of totals[a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value[b]	Index[c]	Value[b]	Index[c]	Value[b]	Index[c]	Value[b]	Index[c]	Value[b]	Index[c]
Steel cans	0.723	100.0	72.3	130.0	94.0	476.0	344.1	460.0	332.6	250.0	180.8
Aluminum cans and ends	.023	100.0	2.3	145.0	3.3	476.0	10.9	460.0	10.6	250.0	5.8
Collapsible tubes	.002	100.0	.2	145.0	.3	476.0	1.0	460.0	.9	500.0	1.0
Rigid aluminum foil containers	.006	100.0	.6	145.0	.9	476.0	2.9	480.0	2.9	250.0	1.5
Aluminum foil converted	.019	100.0	1.9	145.0	2.8	476.0	9.0	480.0	9.1	400.0	7.6
Steel drums and pails	.115	100.0	11.5	290.0	33.4	486.0	55.9	480.0	55.2	100.0	11.5
Metal strapping	.057	100.0	5.6	370.0	20.7	486.0	27.2	480.0	26.9	100.0	5.6
Gas cylinders	.008	100.0	.8	450.0	3.6	496.0	4.0	480.0	3.8	400.0	3.2
Metal caps	.018	100.0	1.8	130.0	2.3	476.0	8.6	460.0	8.3	500.0	9.0
Metal crowns	.029	100.0	2.9	130.0	3.8	476.0	....	460.0	13.3	500.0	14.5
Total	1.000	....	99.9	....	165.1	....	463.6	....	463.6	....	240.5
Index number			100.0	....	170.0	....	460.0	....	460.0	....	240.0

[a] On the basis of tonnage share.

[b] Values from Table 86 comprising the weighted average of the categories; open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

TABLE 88.—*Disposability resistance values of major material groupings by disposal process: 1966*

Material	Incineration	Sanitary landfilling	Dumping	Composting	Salvage[a]
Paper and paperboard	150	160	100	230	210
Metals	460	170	100	460	240
Glass	490	160	100	360	240
Wood	210	270	100	180	450
Plastics	300	270	100	480	330
Textiles	190	120	100	180	250

Source: Midwest Research Institute.

rials in 1966. The calculations are summarized in Table 89. They show that the Resistance Index for all packaging materials in all processes in 1966 stood at 132.5.

The procedure outlined above was repeated for 1976 on the basis of forecast 1976 packaging material and disposal process shares. Tables, rating work sheets, and calculations for both 1966 and 1976 are included in the Appendix.

Limitations and Future Opportunities

Although the methodology developed for this analysis has been found generally satisfactory for a good over-view type evaluation of the disposability of packaging materials, we want to acknowledge and discuss certain limitations in the hope of suggesting opportunities for improvement.

Under the present scheme, materials are placed in one of five categories (excellent, good, etc.) corresponding to numerical values (100, 200, etc.). This is a very broad categorization which cannot be used to distinguish adequately between two materials of the same rank. For instance, glassine paper and containerboard are both ranked "good" in compactibility: both exhibit good deforming characteristics and considerable springback. However, there are considerable differences between the physical properties of these materials, especially when wet; and these are not recognized by ranking both at 200. Similar differences may be noted, for instance, between wirebound boxes and tight cooperage: both rate fair in compactibility, but tight cooperage is far more difficult to handle due to its construction than a wirebound box. The rating scheme used, however, does not permit ranking of these items one against the other.

The refinement limitation is dictated by two factors: first, insufficient empirical data are available to permit making fine distinctions in all cases—although, of course, distinctions can be made in some instances. Second, the extremely large number of configurations (especially in paper, glass, and plastics) would necessitate an unjustifiably great survey effort in identifying the individual configurations and would require thousands of analytical judgments to be made to determine values for such small subcategories as reinforced pressure sensitive tape or pressed pulp egg cartons.

It is also impracticable to attempt to reflect expected 1966–1976 changes in the disposability of materials themselves (e.g., stronger bottles, more coatings on paper, etc.). Improvements and deteriorations identified in our study will not be great enough to cause a change in the valuations assigned to materials under the present rating definitions.

Another limitation is in the area of disposal processes. For instance, for the sake of simplicity, it was assumed that all materials burned in 1966 were burned in well-operated special purpose incinerators of the municipal type (operating at temperatures of 1300 F and above). This, in fact, was not the case and consequently the rating mechanism is unrealistic insofar as it applies to waste tonnage which passed through primitive residential backyard burners. In this case also, lack of detailed information (about the number of backyard, household, and conical burners and their characteristics) was a limiting factor.

Our work to date suggests that systematic evaluation of all waste materials—from packaging and also other sources—could be established on a process-by-process basis by undertaking refinement of the broad-gauge ranking system outlined here. Such an evaluation would involve the gathering of comprehensive field data on processes and on the behavior of various major waste materials in the dominant processes together with laboratory testing to establish new information where historical data are not available. On the basis of such investigations, a refined system of rating definitions could be established and made the foundation of a much more comprehensive evaluation system.

Analysis of Findings, 1966–1976

Summary: To state our findings very briefly, packaging materials—on an average—will be more difficult to process as waste in 1976 than in 1966. The difference will be due primarily to changes in processing methods used. Difficulties associated with changes in packaging materials themselves will cause only a very minor increase in the Resistance Index.

The Resistance Index as calculated for 1966 is 132. The 1976 Index will be 148, representing an increase of 16 points. Of this increase, 15 points (94 percent) will be due to changes in processing—more incineration and landfilling, less open dump-

TABLE 89.—*Calculation of disposability resistance index: 1966*

Material	Tonnage share	Incineration 0.14		Sanitary landfill 0.05		Dumping 0.775		Composting 0.005		Salvage 0.03		Total 1.00
		Value	Index [a]	Value	Index [a]	Value	Index [a]	Value	Index [a]	Value	Index [a]	
Paper and paperboard	0.5475	150	11.497	160	4.380	100	42.430	230	0.630	210	3.449	62.386
Metals	.1557	460	10.027	170	1.323	100	12.067	460	.358	240	1.121	24.896
Glass	.1791	490	12.286	160	1.433	100	13.880	360	.322	240	1.290	29.211
Wood	.0883	210	2.596	270	1.192	100	6.843	180	.079	450	1.192	11.902
Plastics	.0239	300	1.004	270	.323	100	1.852	480	.057	330	.237	3.473
Textiles	.0055	190	.146	120	.033	100	.426	180	.005	250	.041	.651
Total	1.0000	....	37.557	....	8.683	....	77.498	....	1.451	....	7.330	132.519

[a] Material market share times disposal process share times value index.

Source: Midwest Research Institute.

ing. The remaining point (6 percent of the total increase) will be attributable to changes in materials: more paper, more plastics, less metal per average ton of packaging materials, and such changes within single categories as more nonreturnable bottles and fewer returnable bottles.

It is clear that, viewed as a whole, packaging materials as such will only be slightly more resistant in 1976 than in 1966 if disposal processes remain unchanged. Disposal process distributions are expected to change substantially, and the direct technical resistance of materials measured by our index will increase markedly. Since the technical resistance is related indirectly to costs, overall costs will also be trending up.

Ranking of Materials and Processes

Which packaging materials are least resistant to processing? And which process can handle the average mix of packaging materials of 1966 and 1976 with least difficulty? This section attempts to answer these questions on the basis of 1966 and 1976 Resistance Index Calculations (see Appendix).

The relative influence of processing on materials is shown in Table 90; the influence of materials on processing in Table 91. In these two tables, resistance values are shown in terms of either materials or of processes. It is interesting to note that processing changes will result in increases in disposal resistance ranging from 5.9 percent to 21.4 percent depending on the material. Changes in materials, on the other hand, will result in decreases in processing difficulty of 2.5 percent in salvage/reclaiming and increases of 2.9 percent in sanitary landfilling.

TABLE 90.—*Effect of disposal process on disposability resistance index by material: 1966 and 1976* [a]

Material	1966	1976	Percent increase over 1966
Paper and paperboard	114	123	7.9
Metals	160	185	15.6
Glass	163	187	14.7
Wood	135	157	16.3
Plastics	145	176	21.4
Textiles	119	126	5.9

[a] Based on 1966 and 1976 weighted disposal processes.

Source: Midwest Research Institute.

TABLE 91.—*Effect of packaging materials on disposability resistance index by disposal process: 1966 and 1976* [a]

Process	1966	1976	Percent change over 1966
Incineration	268	267	−0.04
Sanitary landfill	174	179	2.9
Open dumping	100	100	0
Composting	290	292	.7
Salvage and reclaim	244	238	−2.5

[a] Based on 1966 and 1976 packaging material distribution.

Source: Midwest Research Institute.

The index values shown in these two tables illustrate the relative resistance associated with materials and processes. For instance, paper and paperboard is the most easily disposable packaging material category both in 1966 and 1967. Glass is the least in both years.

The relative ranking of each major material category in the years 1966 and 1976 remains unchanged:

1. Paper and paperboard.
2. Textiles.
3. Wood.
4. Plastics.
5. Metals.
6. Glass.

Turning to processes, the "best" process (in the sense that materials offer least resistance when put through it) is open dumping. Sanitary landfilling comes next. Materials resist composting most. Processes are ranked as follows on the basis of our calculations in both years:

1. Open dumping.
2. Sanitary landfill.
3. Salvage and reclaim.
4. Incineration.
5. Composting.

Here, once more, the relative changes in the period 1966 and 1976 are not uniform: incineration and salvage values actually decline; the sanitary landfill value increases (nearly 3 percent) along with the compost value (0.7 percent), and open dumping remains the same. It should be noted that the third-place rank of salvage and reclaim is probably unrealistic. Since the index measures technical resistance, not economics, salvage receives a fairly good rank; closer analysis of this process indicates, however, that market acceptance of salvaged materials is poor, owing to the low costs of virgin materials.

Another method of ranking materials is presented in Table 92. Here, the relative dominance of material groupings (in tons) is compared to the the contribution of these materials to the Resistance Index values in two years, 1966 and 1976. Only two materials, paper and textiles, contribute proportionately more to total tonnage than to difficulty. The table also shows that while the resistance of paper and textiles is decreasing, those of all the other materials are increasing. Table 93 expresses these same relationships in terms of disposal processes.

It should be kept in mind, in viewing these rankings, that they are based on packaging materials and their resistance only and do not purport to pass judgment on the overall efficiency or acceptability (from a health standpoint) of processes nor on the overall disposability of all waste materials.

Comparative Resistance Values of Nine Disposal Process Cases

Up to this point, the analysis has been based entirely on forecasts of changes between 1966 and 1976 which we judge to be the most probable. For the sake of interest, however, additional analyses are presented below which are based on possible but less probable developments.

The most significant expected change in processing, in our view, will be the progressive elimination of open dumping across the nation. For this reason, all cases trace the effect on the Resistance Index of the virtual elimination of dumping. The open dumping burden must be absorbed by other processes, and our analysis shows what may be expected, as incineration and sanitary landfilling are called upon to accommodate wastes which were formerly dumped. Table 94 shows the percentages assigned to the processes under the assumptions and, in the last

TABLE 92.—*Comparison of packaging materials and their contribution to volume and resistance: 1966 and 1976*

Material	1966			1976		
	Contribution to total tonnage (percent)	Contribution to 1966 resistance index (percent)	Ratio tonnage to resistance	Contribution to total tonnage (percent)	Contribution to 1976 resistance index (percent)	Ratio tonnage to resistance
Paper and paperboard	54. 75	47. 08	1. 16	56. 86	47. 47	1. 20
Metals	15. 56	18. 79	. 83	12. 96	16. 75	. 77
Glass	17. 91	22. 04	. 81	18. 32	23. 73	. 77
Wood	8. 83	8. 98	. 98	6. 81	7. 22	. 94
Plastics	2. 39	2. 62	. 91	4. 82	5. 72	. 84
Textiles	. 55	. 49	1. 12	. 23	. 20	1. 15
Total	100. 0	100. 0	....	100. 0	100. 0	....

Source: Midwest Research Institute.

TABLE 93.—*Disposability processes and their contribution to materials handled and resistance: 1966 and 1976*

Process	1966			1976		
	Proportion of total waste handled (percent)	Contribution to 1966 resistance index (percent)	Ratio total waste to resistance	Proportion of total waste handled (percent)	Contribution to 1976 resistance index (percent)	Ratio total waste to resistance
Incineration	14. 0	28. 34	0. 49	18. 0	32. 51	0. 55
Sanitary landfilling	5. 0	6. 55	. 76	13. 0	15. 78	. 82
Dumping	77. 5	58. 48	1. 33	64. 0	43. 30	1. 48
Composting	. 5	1. 10	. 45	1. 0	1. 98	. 50
Salvage	3. 0	5. 53	. 54	4. 0	6. 43	. 62
Total	100. 0	100. 0	....	100. 0	100. 0	....

Source: Midwest Research Institute.

TABLE 94.—*Influence of disposal process share on the disposability resistance index: 1976*

Process	Process share in percent									
	Actual forecast	Increasing use of incineration			Increasing use of sanitary landfill			Increasing use of incineration and sanitary landfill		
Incineration	18	38	58	78	18	18	18	28	38	48
Sanitary landfilling	13	13	13	13	33	53	73	23	33	43
Open dumping	64	44	24	4	44	24	4	44	24	4
Composting	1	1	1	1	1	1	1	1	1	1
Salvage	4	4	4	4	4	4	4	4	4	4
Total	100	100	100	100	100	100	100	100	100	100
Index	148	181	215	248	164	180	195	170	197	222

Source: Midwest Research Institute.

line, the index values calculated for each assumption.

The resistances associated with increase incineration are higher than those associated with increased landfilling. Consequently, open dumping volume which is diverted to landfilling shows lower resistance than in a case where incineration absorbs the tonnage previously dumped. Keeping in mind that resistances calculated here are guides to direct comparative costs of disposal, this finding is exactly what one might expect in that incineration is a more costly disposal route than landfilling.

This brief analysis points out one of the potential merits of a rating system such as the one used here for planning future disposal facilities. It is conceivable that the system presented here could be refined to a point where it would permit accurate prediction of the least costly method of handling a future waste volume.

PART III

Mechanisms for Mitigating Problems Caused by Packaging Materials in Waste Disposal

Preceding page blank

Mechanisms for Mitigating Problems Caused by Packaging Materials in Waste Disposal

INTRODUCTION

A variety of activities which may result in the mitigation of problems caused by packaging materials in waste disposal are discussed in Part III of this report. Not all of the activities analyzed are considered desirable or practical. Those that do not appear worthwhile are nevertheless included in the discussion for the sake of completeness and in order to indicate the limits of practical intervention.

Our method of approach is exploratory and begins with a formulation of the objectives that might be framed by the Public Health Service in relation to packaging. This is followed by a discussion of the mechanisms whereby the objectives may be achieved. The mechanisms for achieving the objectives are then evaluated in some detail in light of the objectives. In the next section, barriers to achievement of the objectives are described. Finally, recommendations based on the analysis are presented.

Before proceeding, we should like to attempt an answer to a fundamental question which may be raised in connection with this part of the report. The question is, "Why should a government agency take an active part in mitigating disposal problems caused by packaging?"

The answer derives from the nature of solid waste generation. Solid wastes, much like air and water pollutants, create a problem because their adverse effects are not automatically removed by the workings of the free market. This is best illustrated in the case of packaging by recalling that neither the manufacturer's decision to make a certain package nor the consumer's decision to purchase that package are influenced by consideration of disposability.* The market does not reward either party for making or buying a highly disposable package, nor are there economic sanctions attached to the use of a container which resists disposal processing.

In order to influence either the packaging industries or the consumer, economic rewards must be attached to containers which are disposable and sanctions must be imposed on containers which resist disposal processing. Since neither packagers nor package buyers are likely to impose such rewards and sanctions voluntarily, the intervention of a third party is essential to remove what economists call the "external diseconomies" which packaging creates in waste disposal.

The Federal Government is only one of several such third parties. While the following discussion concerns itself primarily with action on the federal level, appropriate activities could also be pursued on a regional, state, or municipal level. Even privately operated waste disposal corporations and citizen's committees could fulfill the "third party" role, although their effectiveness would be limited and the impacts of their actions on the packaging industries would be negligible.

Formulation of Objectives

If one were asked to sum up in a single word the basic problem which packaging materials represent for waste collection and disposal facility operators, that word would be "cost." Packaging materials are a relatively recent large volume waste product, whose handling can increase solid waste collection and disposal expenditures. Increased costs may show up as a requirement for more collection equipment, the need for a larger labor force, as a requirement for new landfill sites, as higher maintenance and labor costs in incineration, and as a requirement for the addition of air pollution control equipment.

If packaging materials represented a health or safety hazard, the justification for government action aimed at packaging would exist without question. However, with some very minor exceptions—polyvinyl chloride materials which decompose into chlorine compounds when

---

*Disposability here refers to handling the material after a user has discarded it and has no further use for the package.

Preceding page blank

burned—packaging materials do not represent a health hazard. They may give rise to air pollution if they are burned in incinerators which are improperly operated. But pollution is created by the incinerator operator, not packages. Glass or metal containers thrown away carelessly may cut tires or people's feet. But here again, the fault lies with those who litter, not with container manufacturers. Finally, food wastes or chemical residues left in containers can create ground water pollution or serve as nutrient to insects and rodents; in such instances, also, the containers do not cause the health hazard.

Public Health Service activities related to packaging must, consequently, encompass these economic objectives. Objectives which embrace all basic economic problems created by packaging can be formulated as follows:

(1) Reduce the quantity of packaging materials used, thereby reducing the quantity of such wastes which must be transported and handled.

(2) Reduce the destruction of valuable natural resources.

(3) Reduce the technical difficulty of handling such wastes in disposal or salvage facilities.

(4) Dispose of solid wastes more effectively and efficiently by known methods such as landfill and incineration and by new approaches to solid waste processing.

MECHANISMS FOR ACHIEVING OBJECTIVES

Generally, mechanisms for achieving the objectives outlined above are: regulation, creation of incentives, imposition of taxes, pursuit of appropriate research and development efforts, and educational efforts. More specifically, the following activities appear suited to each objective.

Reduction of the Quantity of Packaging Wastes Generated

There are two ways in which the quantity of packaging materials which end up as waste can be reduced: (1) regulation of the packaging industry to eliminate "overpackaging" and (2) regulation forcing the reuse of containers or recycle of the materials for reprocessing.

"Overpackaging," as used here, refers to a tendency in retail commerce to use more packaging than is absolutely necessary for product containment and protection. As used in industry, the term refers to quality rather than quantity; in industrial jargon, a product is overpackaged when a more costly material is used than is necessary.

It is our conviction that many products are overpackaged in the sense that quantitatively much more packaging is used than is necessary. Potato chips in bags are sufficiently packaged. They need not *also* be in boxes or tins. There is, similarly, no technical justification for packaging many small, durable items on display boards via blister or skin packaging; however, there are commercial reasons for doing so.

Concerning reuse and recycle, it should be noted that most packages cannot be reused because they are not sufficiently durable or they become contaminated during use. Recycling is theoretically more possible if adequate technology for separating and reprocessing of materials is first created. That is, with the exception of returnable containers as such, if the packages are reduced to their raw material state they can be used again.

Conservation of Natural Resources

To accomplish this aim, three means seem suitable: (1) prohibition of use of certain materials in packaging applications; (2) regulation requiring that containers be made of specified materials and be returnable and reusable; and (3) improvement of salvage and conversion by making packaging waste more salvable; by rewarding those who use secondary materials or, conversely, by taxing virgin resources; development and use of more salvable materials; and by aiding salvage operators.

This objective overlaps somewhat with the first one—reduction of the quantity of packaging materials which must be handled. The chief difference between the first objective and this one is in point of view. Whereas it may be difficult to justify government action for the purpose of regulating industry and thus aiding disposal facility operators, it may be possible to justify action on the grounds that vital national resources are being wasted needlessly.

Reduction of the Technical Difficulty of Handling Packaging Wastes in Disposal Facilities

Three ways of achieving this objective can be identified: (1) modification of packages to give them characteristics which better fit disposal system requirements; (2) elimination of materials which are "undesirable;" and (3) development of new disposal technology which can handle packaging wastes with less trouble and cost.

Package modification may be accomplished by one or more activities, among them educational efforts, development of new design criteria, R&D effort, and use of the government's purchasing leverage. This is a potentially promising approach to mitigating some problems created by packaging in waste disposal.

Elimination of undesirable materials, by whatever means, implies thorny legal and administrative problems which will be fully treated below.

Development of new disposal technology generally falls outside the scope of this analysis since packaging materials represent a small part of total waste, and process development must take all wastes into account.

EVALUATION OF MECHANISMS

Mechanisms for achieving the objectives include: (1) support of research and development; (2) educational activities; (3) incentives and subsidies; (4) taxes; and (5) various forms of administrative regulation. A detailed discussion of each mechanisms will be presented.

Research and Development

R&D can be performed by the Public Health Service in-house; research by qualified profit, nonprofit, and university groups can be supported by contracts or grants; finally, R&D activity in industry can be aided, supported, or encouraged.

In relation to packaging, research and development can be oriented toward three basic areas: development of materials which are more easily disposed of, separated, and reused; development of a technology of salvage and reuse; and development of disposal technology that will be capable of handling packaging wastes without trouble. This last area of research appears to be the most promising, but as previously mentioned is outside the scope of this analysis. Research devoted to the improvement of salvage technology would also be promising.

Materials Research

Least fruitful, in our view, would be effort expended on changing the characteristics of packaging materials. The primary reason for this is that exactly those characteristics which make a package difficult to handle in disposal are those which make it desirable as a package. This is a way of saying that any container which is easily disposed of is a poor container; and while such a generalization could not be applied to all packages, it is applicable to those packaging categories which create difficulty in disposal.

Changes in materials and containers which would be desirable from a disposal point of view are these:

(1) *Plastics*—should have better burning rates so that they will not create trouble in incineration; should be degradable in soil; should be made easier to separate by some mechanical means.

(2) *Steel*—if tin and lead were eliminated from steel cans the steel would be more acceptable for salvage; nonferrous metals (aluminum ends on steel cans) make the steel less acceptable in salvage; containers should be made in such a manner that they can be flattened, crushed, or collapsed with modest pressure by the housewife without use of tools or machinery.

(3) *Aluminum*—currently two or more types of aluminum alloys are used to make a can; a single-alloy can would be more desirable from the salvage point of view.

(4) *Paper*—synthetic coatings (clay, plastics) and photogravure inks create problems in repulping or deinking; coatings and inks should be created which provide presently obtainable characteristics but do not cause problems in reuse of the paper.

(5) *Glass*—containers should be easier to break without losing their strength in use; when broken, glass containers should fall apart into uniform pellets, not slivers and shards that create safety hazards.

As can be seen from the above, some of the desirable characteristics are not obtainable without significantly changing the molecular structure of the materials, thereby changing their vital characteristics (more flammable plastics and new paper coatings). To change other characteristics would call for the creation of new container types which would cost considerably more than currently available packages (glass and collapsible steel). Yet other changes are much more practical—tinless steel and single alloy aluminum, which are already beginning to be used commercially in packaging.

While research directed at achieving some of these changes is justified, particularly if the material modification would aid in the recovering of packaging materials for reuse, we believe that R&D expenditures on the development of disposal or salvage technology would be more fruitful.

Most of the difficulties created by packaging are due to inadequate technology or the absence of technology in waste disposal. So long as wastes are landfilled without prior shredding and grinding, glass, plastics, and aluminum containers will be deposited in unaltered form and will retain their form. Ground up thoroughly, small bits of glass, metal, and plastics would be much more acceptable as fill material, even if they did not degrade or decompose. In incineration, more sophisticated combustion techniques could eliminate problems caused by plastics. Or separation of plastics by some automatic means followed by separate burning in specially designed incinerators to alleviate the problems of grate fouling which are encountered when shock loads of plastics are burned could be used as a solution. In the same vein, development of effective, low cost, automatic materials separation technology would be a more practical aid to composting than development of degradable plastics—and would probably be less costly and more likely to succeed as well.

Public Health Service research efforts aimed at packaging materials and containers should be restricted, in our view, to encouragement of industrial developmental work to bring about early commercialization of tin-free steel cans, single alloy aluminum, and new paper coatings. All of these developments would aid salvage. Other desirable materials changes which would make packaging easier to dispose of appear to call for inordinate R&D efforts. Once materials with the desirable characteristics are obtained in the laboratory, they would have to be demonstrated as economic alternatives to existing materials. Finally such R&D effort may turn out to be unimportant as disposal technology is improved.

Salvage Technology Research

The research goal most worthy of pursuit would be the development of automatic materials separation techniques. At present, only steel cans can be separated from waste effectively, using magnets. Air float systems can be employed to sort out light materials—but plastic films and paper are indiscriminately mixed in such systems. Inertial and ballistic systems can sort out heavier nonferrous materials, but these too produce mixtures of glass aluminum, plastics, wood, etc. To achieve effective separation, invariably involves hand sorting of wastes, which is a costly activity and unappealing to the workers.

Absence of systems which could selectively and automatically separate wastes is one of the real bottlenecks in waste handling and reuse. Development of such a technology would seem feasible and would involve the mating of technologies developed in several industrial activities: (1) sensing techniques used in the process industries, aerospace, and medical electronics; (2) materials handling technology developed for agriculture (automatic harvesters); for food handling (e.g., American Machine & Foundry's automated short-order kitchen); for packaging; for metals fabrication, etc.; (3) computer and/or numerical control technology used in metal working, electronic data processing, and process control; and (4) materials tagging, marking, and tracing techniques.

Research efforts in this area would involve identification of sensing techniques which could recognize and classify waste materials with little or no modification; marking of those materials which cannot be sensed, for example, by infrared sensitive materials; and combination of sensing techniques with materials handling equipment in an operating system. Feasibility of such a technique could be explored in phases, and we recommend that Public Health Service undertake or contract for the first phase of this research, a state-of-the-sensing-art evaluation performed to discover the match between existing technology and segregation requirements in waste handling.

Some strides have recently been made in waste materials preparation and handling equipment in steel with the advent of the Proler steel shredder. Support by the Public Health Service of similar endeavors to improve waste materials handling would be appropriate to improve salvage. An example of such effort would be funding of an ongoing effort to develop a waste paper shredder-pelleter which promises to automate containerboard reuse by reducing these containers to uniform pellets.* These bulky containers are typically shipped in bales, stacked in tall piles in warehouses, and conveyed from point to point by fork-lift trucks.

Other activities to improve salvage technology might include development of processes for separating plastic coatings from paper and automated sorting of glass and plastics by color.

Educational Efforts

Educational efforts, some formal some informal, are already under way under the auspices of the Bureau of Solid Waste Management, Public Health Service. In what follows, specific programs will be discussed and directed at three groups: industry, including sanitary facility operators; the consumer; and governmental agencies within the federal establishment.

The objective of all of these efforts should be to disseminate, exchange and/or develop in suitable form information concerning packaging materials and their performance in waste disposal or salvage facilities, on the assumption that the recipients of the information will voluntarily modify their activities as soon as they clearly perceive the problems involved.

The above assumption is optimistic but sound. Many of the individuals and organizations involved in packaging, directly or indirectly, face constraints other than lack of information. These constraints will not be removed by educational efforts, and the actions of those involved may consequently not be modified. But in those instances where the primary constraint is ignorance, educational programs can be expected to be effective, especially if they are combined with other activities such as disincentive programs, regulation, supporting research and development, and incentive programs.

Industry Programs

To produce packages which are easy to process in disposal facilities has not been one of the traditional aims of package manufacturers. At least one reason for this has been a general lack of information about the disposal problems packages can cause. Another has been public apathy concerning the entire question of waste generation and waste disposal.

In recent years, public interest in solid waste has been aroused. The popular press is full of articles on this subject. Some have viewed the problem with alarm, have suddenly discovered the "crisis" proportions of solid waste generation, have warned that we will be inundated with empty beer cans, plastic bottles, and soft drink bottles, etc.

The trade press has also been active in presenting the subject from various angles. At the same time, the establishment of a federal-level program—the Bureau of Solid Waste Management of the Public Health Service—to aid in the solution of pressing waste disposal problems has raised the subject to national prominence.

Keep America Beautiful and other organizations have existed for some years through the support of industry. The primary thrust of their activity is directed at litter. More recently, several major packaging companies have assigned full time staff members to direct attention to other aspects of solid waste besides the more common emphasis on litter. The Glass Container Manufacturers Institute in 1967 added a full time "manager of environmental pollution control programs." Another industry group—a "Materials Research Council"—was formed in late 1967 to evaluate actions that industry might take to deal with packaging solid waste. This latter group is composed of representatives of several major packaging companies. Other industry associations have special committees or groups to evaluate the role of packaging in solid waste. However, they are mostly concerned with litter or have been limited to a brief survey of "the solid waste problem."

To date these industry efforts taken as a whole are nominal. In some instances, the principal aim of industry action appears to be to counteract unfavorable legislation aimed at a particular material or container type. However, the majority of companies taking the initiative in this field appear to be sincerely interested in attacking the problems in a realistic manner.

Such voluntary efforts have considerable promise in our opinion and should be supported to the fullest by the Public Health Service. The mechanism for so doing would be educational programs.

What might such programs accomplish? Perhaps the most important aim would be to remove some of the misunderstandings which separate industrial and government officials (at all levels). Industrial leaders have a tendency to view all government action, however remotely connected with their activities, as a potential threat. There also seems to be a widespread conviction in industry that government officials connected with solid waste handling view the packaging industries as somewhat negligent or indifferent to disposal problems. The fact that both of these views can be substantiated with isolated examples does not help matters.

---

*Detailed information concerning this machine may be obtained from the National Committee for Paper Stock Conservation, Chicago, Illinois.

The real root of these misunderstandings is lack of communication between industry and government. That is not to say that an open exchange of views would remove some of the actual differences which exist between packagers and disposal facility operators. But so long as such misunderstandings exist, a rational approach to the reconciliation of differences remains blocked.

It is our recommendation, consequently, that the Public Health Service take the lead in bringing together representatives of the packaging industries and local sanitation officials, researchers, and federal and state officials in regional conferences, symposia, and seminars.

The Public Health Service should endeavor to conduct such meetings in an informal, off-the-record atmosphere. The object of the meetings would be to air problems and grievances, to discuss research requirements, the constraints faced by the packaging industries, and similar pertinent subjects. We expect that the outcome of such exchanges would be favorable. They would lead to package modifications undertaken voluntarily; to modifications of waste processing suggested by packagers, whose familiarity with their materials would aid processors; and to the improvement of recycling and reuse of waste materials.

A second aim of educational programs would be to make available to all interested parties a sufficiency of existing information, in easily usable form, on waste disposal, packaging, and other appropriate subjects. At the present time, it is not possible to obtain on short notice and with little effort a summary of all publications on, say, the subject of incineration. To obtain such information requires the expenditure of considerable effort in searching the available literature. If the aim of the investigator is to analyze the combustibility of plastics in municipal incinerators, his task would be doubly difficult.

To fulfill this second aim, we recommend that the Public Health Service establish a Solid Waste Disposal Technology Information Center, operated either as a free service or on a subscription basis.

The Information Center would store all literature on a variety of subjects pertaining directly or in an ancillary manner to solid waste technology; thus, in addition to literature on the technology of disposal and collection, it would store data on the volume and character of wastes, waste generation, the composition and performance characteristics of materials, health aspects of solid waste, information on special waste problems such as agricultural manures and building rubble, information about secondary materials markets, etc. Such a system could be designed as an extension of the Solid Waste Information Retrieval System (SWIRS) currently operated by the Office of Information of the Bureau of Solid Waste Management.

Organization of the information should be such that comprehensive searches embracing more than one subject could be undertaken by the use of key words. This suggests that the system would have to be automated (if not computerized). Monthly abstracts of inputs could be published by the center to familiarize users with new information available.

Periodic assessment of the data stored and of incoming information requests would reveal data gaps. These could be filled by appropriate investigations in-house or by outside research organizations; if data would be available from industrial sources, corporations could be requested to supply the information needed.

Consumer Programs

The programs outlined above would reach principally industrial organizations including industry associations and sanitary facility operators. This leaves out of account an important third party—the consumer. A widespread change in public attitudes toward solid wastes and packaging would do much to create a favorable environment for mitigating problems created by packaging. In a section which follows on barriers to action, consumer attitudes are cited as an important deterrent to the achievement of Public Health Service objectives.

The aim of any consumer education effort would have to be to create a willingness to cooperate with waste disposal organizations and packagers in various ways. The campaign against litter is an example of such an effort. While not visibly effective except in isolated instances, it would be accurate to say that anti-litter education helps to curb the growth in littering and is effective in inculcating proper attitudes in children, who may be the litterbugs of tomorrow.

Similar programs touching on other areas of waste disposal activity would also be effective. Among such programs might be efforts to create an awareness in the public mind of (1) the costs and technology of disposal; (2) the volumes of wastes generated, with special emphasis on packaging; (3) the "squander" aspects of waste disposal; and (4) efforts to show how the consumer can help waste disposal facility operators (buy returnable containers, flatten cans, crush nonreturnable bottles and jars, support local programs of salvage and reclaiming, etc.).

Such programs could be pursued best in cooperation with voluntary private social service groups—Keep America Beautiful, Inc., National Educational Television Network, church groups, the Boy and Girl Scouts, etc. Public Health Service contribution to such efforts might take the form of supplying information, films, and financial assistance.

Intra-Government Information Programs

There are five federal agencies which have a fairly direct influence on packaging: the Consumer and Marketing Service of the Department of Agriculture; Defense Supply Agency, Department of Defense; the General Services Administration; the Food and Drug Administration, Department of Health, Education, and Welfare; and the Interstate Commerce Commission.

None of these departments and agencies concerns itself with the disposability of packaging materials. At the same time, however, they have the power to influence packaging materials in various ways.

For instance, polyvinyl chloride plastics in the glass-clear form could not be used in food packaging until FDA approval of the material had been granted for the modifying additives used to obtain clarity. While this material has been found acceptable by FDA under its present criteria, it is not a very desirable material from the waste disposal point of view when it is incinerated because on burning the plastic decomposes into potentially hazardous chlorine compounds. Modification of FDA licensing procedure to take into account potential material hazards arising in disposal might have prevented use of this material in food packaging.

Intra-governmental information programs would have as their first aim to acquaint all those concerned with packaging, either in a regulatory role or as purchasers, with desirability criteria developed by the Bureau of Solid Waste Management, Public Health Service. Once this is accomplished, cooperative effort to work out modified specifications and purchasing standards could be undertaken.

What is proposed here is, essentially, educational programs leading to regulatory action or to incentive type programs. FDA and Interstate Commerce Commission action, for instance, could be used to prevent the widespread use of undesirable materials or configurations—by withholding permission to use a material in certain applications or by influencing its transportability. Government purchasing, based on criteria which embrace disposability, would serve as an incentive for the development of packaging products which better fit disposal requirements.

These programs, to be of maximum effectiveness, would take the form of interagency task forces or study groups and should not be restricted to the dissemination of documentary materials to agency staffs, although that may be a suitable first step.

The effectiveness of educational efforts would be extremely difficult to measure. For this reason, cost/effectiveness yardsticks would prove largely useless, with the result that justifying such programs would be somewhat difficult. This would be particularly true in the case of expenditures on consumer education. However, the levels of expenditure involved would also be modest. For instance, a Waste Disposal Technology Information Center could probably be operated for under $200,000 annually (Table 95). Two-day regional seminars, if held on government property, could probably be staged for $7,000 each in expenses for program printing and mailing, audiovisual support, intra-city transportation, coffee, production of proceedings, and a concluding dinner for 50 participants.

TABLE 95.—*Estimated annual cost of operating a waste disposal technology information center* [a]

Personnel and equipment	Cost
Staff—salary and overhead (3 senior analysts, 1 secretary/clerk)	$100,000
Staff travel and telephone	50,000
Production, reproduction, and mailing expenses	45,000
Equipment allocation:	
Automated information retrieval system [b]	2,000
Other equipment [c]	500
Total annual outlay	197,500

[a] Excludes the costs of special studies undertaken to fill data gaps and assumes an operating system. First year operating costs would be higher.

[b] $10,000 system, 5-year depreciation.

[c] $5,000 in equipment, 10-year depreciation.

Source: Midwest Research Institute.

Incentives and Subsidies

Various forms of incentives have been used by the federal government for decades to achieve desired objectives. In general, incentives in this analysis would be any expenditures of tax receipts made by the government, or use of the government's purchasing power, to bring about changes in packaging materials use or reuse. Expenditures can be either direct (subsidies, outright grants, price support) or indirect (tax credits). It is important to keep in mind throughout the following discussion of incentives that such measures can also be viewed as indirect taxes. For example, any incentive payment which results in increased use of waste paper is also a hidden tax on virgin pulp because the incentive helps to narrow the gap between the costs of obtaining and processing these two raw materials.

The Question of Justification

The basic difference between use of incentives and subsidies and regulatory authority is that incentive type programs are commonly used by the federal government to bring about changes considered necessary for the public welfare; whereas regulation is practiced only as a last resort.

Government subsidy of desalination development, atomic energy, the supersonic transport (SST), water treatment facility construction, solid waste disposal technology development, highway construction, shipbuilding, agricultural price supports, and a host of other activities are examples of government use of tax funds to bring about changes in the economic and technological environment. Some of these activities are also indirect taxes on commodities and services. Support of atomic power development, for instance, is an indirect tax on hydrocarbon fuels; subsidies of the shipbuilding industry are an indirect tariff on more efficient foreign shipbuilding companies which, given an unsupported U.S. shipbuilding industry, might for a time capture all of the U.S. shipbuilding business.

In view of this situation, justification of incentive type programs aimed at improving packaging material disposability and salvability should present no problems.

Incentives and Salvage

Incentive type mechanisms appear to have the best chance of being effective in attempts to improve salvage. This, in turn, would result in a reduction of total packaging material tonnage entering the waste stream and would contribute to the conservation of valuable natural resources.

Salvage and reuse have been declining in the United States because our natural resources abound and because virtually all raw material development efforts have been focused on the efficient winning, purification, and conversion of virgin materials. Research and development work to utilize wastes and to process and move them efficiently has been minimal since the value of secondary materials has been low in relation to virgin materials, and scrap and waste handling organizations have consequently not had the incentives to improve their technology and to invest capital in innovative ideas.

In order to increase significantly the quantities of waste materials which are used as virgin substitutes, it would be necessary to bring about a series of changes and improvements in the secondary materials industries which—had the nation suffered shortages in the past—would have been brought about by the natural workings of the market. The reasons for doing so are twofold: first, higher secondary materials use rates would ease the load on waste disposal facilities; and second, higher reuse ratios have to be achieved as we slowly but inexorably approach the point where total demand from population increase and rising living standards at home and around the world begin to strain our virgin resources.

Five specific ailments afflict the secondary materials industries:

(1) Collection systems are inefficient, inadequate, or nonexistent.

(2) Wherever practiced, collection is frequently sporadic except collection of materials with fairly stable markets like scrap iron and steel.

(3) Materials handling technology—separation, reduction, storage, movement—is frequently inferior to analogous virgin materials handling technology.

(4) Secondary materials prices are highly erratic, which discourages investments in new technology and prevents development of efficiently operating collection systems.

(5) Secondary materials are inferior to virgin products because they are less homogeneous and frequently polluted, and consequently they are not in demand as substitutes for easier-to-process virgin stocks.

Improvement of salvage generally would require an attack on all of these ills. Incentive type programs could be used with telling effect to solve a number of these problems. Collection systems could be established by subsidy of appropriately deployed existing organizations, for instance scrap companies, Goodwill Industries, Inc., the Salvation Army, etc. Capital could be made available to secondary materials companies to improve their technology—better separation equipment, shredders, pelleters, balers, automated warehousing, and the like. Price supports for secondary materials could be used to maintain a strong and continuing collection effort regardless of price swings. Potential secondary materials users could be encouraged to use, or use more of, such materials by subsidizing the necessary investments they must make in plants and facilities to store, convert, and/or purify such materials.

Of these possible activities, two appear to be the most likely to result in a marked improvement at lowest cost: price supports of secondary materials and tax credits for scrap processors and materials-using industries to stimulate their investment in necessary secondary materials processing and using plant. Both actions would have multiple effects. They would make secondary materials more attractive to collect and process; they would assure a steady supply of these materials, thereby making them a secure source of raw materials; they would permit more careful segregation and pre-processing of wastes, thereby making them more attractive to buy; and they would provide the wherewithal for technological improvements.

Today, an important barrier to waste reuse is the fact that prices paid for wastes are not high enough to permit their processing into truly useful commodities. Heterogeneous waste paper, for example, cannot be sorted to the degree necessary at going prices. Similarly, repulping and deinking costs tend to be high unless the papers processed are already fairly well sorted. It thus becomes necessary, in order to improve this situation, to make up the differential between sales price and processing costs, leaving a margin for profit. Similarly, the plant and equipment needed to repulp these materials must be created. External action is called for to make the use of secondary materials at least comparable in attractiveness to developing virgin resources.

The scope of this study did not permit detailed analysis of the secondary materials industries. Consequently, further investigation should be undertaken to establish exact levels of price supports that would result in maximum recycling at an acceptable cost for each of several commodities. Such a study, however, should focus on all secondary materials, not just packaging wastes. Furthermore, the investigation should attempt to compare two alternatives: support of secondary materials reuse, giving appropriate credit for materials conservation, and support of waste disposal facility operations. It may turn out that the latter course would cost less overall.

Incentives to waste materials users and dealers could take two forms: (1) an investment tax credit, which would permit a corporation to deduct a specified percentage of an investment from income tax, and/or (2) an accelerated depreciation rate which would permit the corporation to write off the investment in a specified period of time, usually shorter than that allowed for a similar class of investment; an accelerated depreciation allowance may also include special provisions such as, for instance, a one-time additional depreciation deduction.

Credits and allowances of this type may be given for construction of production plants which use high proportions of waste, e.g., paperboard mills and electric steel furnaces, and for purchase of waste handling equipment such as shredders, balers, and the like. In this instance also, further investigation is in order to ascertain the probable effects of various tax incentive programs.

The two incentive type mechanisms discussed above have the merit that they could be applied on a national scale with relatively modest administrative programs. In contrast to these programs, the use of incentives to improve secondary materials collection by some direct method (price supports would improve it indirectly) would require a considerable amount of investigation of collection practices in the large municipalities of the nation. Investigation would have to center on: (1) the nature of existing collection systems, including such aspects as distance of the city from using industries; (2) identification of potential organizations which might become bases for secondary materials collection activities; (3) assessment of the problems confronted by both groups of organizations; and (4) analysis of the incentives which may bring about changes in the locality. Most probably, separate programs tailored to the needs of each city would have to be worked out and administered.

Incentive programs of the type discussed above would not be suitable to the modification of containers to achieve packaging wastes which are less contaminated and consequently more salvable. Whereas contamination of wastes is due in part to such things as use of material combinations in packaging, they are no less due to the fact that wastebaskets and trash barrels are used to hold every kind of discard, paper as well as plastics, cigarette ends along with apple cores, garbage and ashes, magazines and yard clippings.

Government Purchasing Policy as an Incentive

In 1966, the Federal Government spent $76.9 billion on goods and services. According to the best available estimates—by Business and Defense Services Administration, General Services Administration, trade associations, and private industry calculations—federal spending on packaging materials was something in excess of $1 billion in 1966, about $850 million in the form of packaging purchased as part of products and commodities, about $150 million in the form of packaging purchased directly as containers, e.g., boxes, cans, pallets, etc.

These expenditures, representing nearly 6 percent of all packaging, were made for packaging products whose characteristics were laid down in comprehensive detail in specifications formulated by either the General Services Administration or the Defense Supply Agency of the Department of Defense, the agencies which purchase almost all products, commodities, and packaging used by federal agencies.

The situation sketched out above points up the significant purchasing leverage exercised by the government which could be used as a direct force to influence packaging. By specifying the use of materials and container types most suitable for disposal, salvage, or both, government purchasing power could be employed to ensure that the government itself does not contribute to disposal difficulty and squandering of natural resources. More importantly, however, such action could also have an important effect on nongovernment packaging by creating the base for technological innovation.

To give one example, it would be possible to spur commercialization of a tin-free steel can by specifying that all foods, canned beverages, and other canned goods purchased by the government after a certain date must be in steel cans which do not contain tin, or that tin-free steel cans will be given preference in competitive bids. Such a specification would create a large market for such containers at a stroke and would thereby remove a portion of the risk of developing such packaging. Exploitation of this new technology for commercial purposes would be almost certain to follow—in packaging any innovation is potentially profitable because it can give a product a "new and improved" image. Ultimately, inclusion of steel cans in scrap iron bundles would become feasible as tin, an unacceptable impurity, is eliminated.

To accomplish such objectives would require establishment of close working relations with GSA and DOD to formulate mutually beneficial objectives. Early targets for joint action might include, in addition to the recently developed tin-free steel can, such things as a single-alloy aluminum can; degradable paper coatings, laminants, and adhesives equal in performance to plastics;

limitation of the types of plastic materials which may be used in packaging; development of material identification systems which could be used in manual or automatic waste segregation; development of glass containers that shatter without resulting in jagged slivers; and similar changes and modification.

Taxes

Two kinds of taxes will be discussed under this heading, a use tax and a deterrent tax. A use tax would be one imposed on packaging in order to raise sufficient revenues to pay for its disposal; such a tax would influence package material or container selection only indirectly. A deterrent tax is one imposed on either a packaging material or a container configuration in order to achieve one or more of the objectives formulated at the outset of this analysis—a way to limit use of a material by artificially raising its price.

The Concept of Packaging Use Tax

A use tax on packaging would be a tax levied on all packages, whose aim would be to obtain sufficient revenues for the disposal of the packages in the most efficient manner permitted by present disposal technology. Basically, under this concept, when a consumer pays for a package, he pays for its disposal.

Such a concept has several advantages over a deterrent type tax, to be discussed below: it would be easier to justify; it would be less discriminatory for it would be applied to all packaging; it would be less likely to disturb free materials selection by packagers; and while providing the economic base for the best possible disposal practice, it could also be used to spur reuse of containers and recycling of materials.

The concept has some intrinsic and potential disadvantages, among them the need for an elaborate machinery to administer the tax efficiently; the possibility that the consumer may be charged twice for the same service; the fact that such a tax may be viewed as a "license to pollute"; the possibility that revenues may be used for other than their intended purposes; and, finally, the fact that such a tax would neither reduce packaging waste quantities, nor reduce the technical difficulty of processing, nor would it eliminate waste of natural resources. It would, however, attack the fundamental difficulty created by packaging materials, that of high disposal costs.

A packaging use tax might work in this manner:

(1) It would be imposed on the finished container, not on the packaging material.

(2) The amount of the tax would vary depending on the resistance of the container to disposal. The basis for the level of the tax to be imposed could be the resistance index presented in this report. Needless to say, the index would have to be refined considerably before it could be put to use.

(3) Funds obtained would be channeled to disposal facility operators on the basis of local collection rates and/or population served. Salvage businesses would also be supported from such a tax on the basis of tonnage of materials they remove from the waste stream. Thus, a salvage company which recovers a certain tonnage of steel cans or corrugated board for reuse would be able to claim the disposal use tax levied on the packages he recovers because he has accomplished disposal of these materials.

(4) Ideally, such a tax would be determined at the national level. However, it could be administered on a state level also or on the local level following state enabling legislation.

(5) The tax would be collected on the local level from the retail merchant (or purchasing industry), whose obligation it would be to show the tax as part of his mark-up, to maintain adequate records, and to pay the tax either to a federal, state, or local agency. He would be permitted to retain a percentage of the tax to cover his collection expenses.

The basic technical problem in connection with this concept would be that of working out the exact level of the tax to be imposed. For maximum fairness, the tax levied on a particular package would have to reflect its disposability, thus rewarding those containers which are easily disposed of. If the system is precise enough, it would act, indirectly, to bring about packages which are more desirable from a disposal point of view. Determining the tax on the basis of disposability would call for the establishment of an extensive package tax bureau within the federal establishment, capable of rapidly evaluating new packages and modifications of old packages. The manufacturer would need to submit his package to the

Bureau for evaluation. The retail merchant would have to maintain long and constantly changing lists of packages, each with its particular disposal fee. New record-keeping tasks would also be imposed on scrap and waste handling organizations. It is not difficult to imagine the kinds of controversies and litigation which may arise in the course of administering such a tax.

To fulfill the basic objective of such a tax—to raise revenues for waste collection—it is not necessary to determine a specific fee for each package type. Broad fee groupings would suffice. However, in such a case, one of the secondary benefits of such a tax, that of bringing about desirable changes in packaging, would have to be sacrificed.

Another problem would be that of "double taxation," whereby the consumer, having paid the disposal fee on packaging materials at the store, would also have to pay for the disposal of his refuse, including many other things in addition to packaging, to the trash collector. Such a situation would be unavoidable unless all other items which are discarded are also taxed for purpose of disposal; some items, like yard clippings, building rubble, etc., would be difficult to fit into such a system.

A package disposal fee could be viewed by some people as a "license to pollute," and may cause more littering. Congress is also generally opposed to measures which may be interpreted in this way. For this reason, effluent taxes have not been viewed with favor by Congress even though they are accepted control mechanisms in Europe.

Disposal fee income would have to be allocated with care to local government bodies so that such funds would be used for their intended purposes, not for the fulfillment of other, perhaps equally desirable, goals. Controversies surrounding the use of gasoline taxes point out some of these problems, and unsatisfactory experience with use taxes generally could act as a barrier to the acceptance of a disposal fee concept.

In spite of these many problems, a disposal fee type of tax should be analyzed in detail as a potential mechanism for easing the economic plight of waste handling organizations. The analysis should embrace not only packaging materials but all disposable commodities and should be a two part investigation. Part I would explore the reaction of industrial, commercial, and government executives and legislators to the proposed tax concept; Part II would involve technical assessment and preparation of recommendations dealing with the system to be used for determining the level of the tax, the type of agency that should administer it, and the manner in which it would be administered. Such an investigation would then be used as the basis for legislative proposals.

A Deterrent Tax

An example of a deterrent tax would be a 1 cent per pound imposition on all plastic resins used in packaging applications or a 1 cent per unit tax on nonreturnable beverage containers. The basic principle at work in this case is that of selective taxation, with materials and configurations singled out for taxation on the basis of disposal criteria.

While such a tax appears a potentially attractive tool for guiding packaging materials choice and container design, we doubt that it could be justified and believe that its effectiveness would be difficult to predict.

The basic problem is that such a tax would of necessity be discriminatory since it would be imposed selectively. For instance, it may be desirable from the point of view of an incinerator operator to keep the amount of plastic wastes to a minimum because plastics in high concentrations create problems. Significantly, the problem arises as a result of concentration, not because of material composition as such. A tax on plastics would be difficult to justify on such grounds unless higher taxes are imposed on other materials which do not even burn, and unless configurational characteristics are also taken into consideration. For instance, plastic films and plastics appearing as very thin coatings on paper do not cause trouble in incineration. Therefore, they should not be taxed to the same degree as plastic boxes or bottles.

Justification would be similarly difficult in the case of container types. Since bottles and cans for beverages are conspicuous as litter, it may appear desirable to tax nonreturnable type containers to limit their sales appeal. It may be argued that the vast majority or orderly citizens who do not litter but do desire "disposable" packaging would be unduly penalized for the activities of a few anti-social members of the population. If, on the other hand, nonreturnable beverage containers are taxed because they represent a waste of resources, it would be difficult to justify such a tax without also taxing all other nonreturnable containers—the bulk of packaging. Yet again, a tax imposed on no-deposit beverage containers because they *could* be returned and have been returned in the past is open to the charge that whatever applies to beverages applies equally to other commodities sold in glass and cans. Once upon a time, almost all packaging was returnable.

Deterrent type taxes would have widely varying effectiveness, even if justification were found for imposing them. If the aim is to eliminate or substantially curb consumption of a material, a deterrent tax would have to be made high enough to have an effect on those applications where price of the package is not the dominant consideration. Such a tax would, in effect, price the material out of the packaging market and would be a form of indirect regulation. Direct regulation may be more desirable, in such a case, because changes in technology or consumption would not affect the prohibition, which would be possible if the deterrent is a tax. For instance, a high enough tax on plastics may force them out of packaging. Producers would then presumably look for other outlets. Assuming, for the sake of the argument, that they would find a large volume market—automobile bodies, building materials, paving materials, paper substitute in publishing—the resin price may drop low enough so that packaging applications would become feasible for plastics in spite of the tax. If plastics are prohibited outright, they could not reappear in packaging following substantial price drops.

If the tax is not designed to drive a material from the market, its effectiveness would be restricted to those applications where package costs, rather than package performance, are critical. In the case of plastics, for example, which have won a place for themselves in packaging on the basis of performance, the effect of a tax would be less acute than on paper, which dominates packaging because of its cost advantages. While it would be possible to calculate a tax which would force plastics from the market, it would be difficult to determine what effect a lesser imposition would have because package cost in itself is not the only determining factor in many applications where plastics are used.

It is well to recall, in this connection, that the price of a product sitting on a grocery or drug store shelf is based on a variety of cost and noncost considerations. These would include: cost of the product, cost of the package, cost of distribution, cost of advertising and promotion, expectation of volume to be sold (which affects all costs already cited), and a judgment of the product's value to the consumer. Concerning the last point, many products, especially luxuries, cosmetics, toys, novelties, hobby goods, and the like have prices which do not relate directly to total cost of production and distribution. At the same time, package qualities (appearance, communication potential, etc.) are more important in these product categories than package performance. The chances are that the manufacturer already pays a premium for quality and would not be deterred from using a particular material or configuration if it is taxed, unless, of course, the tax is prohibitively high.

If glass or metals are taxed, a somewhat different situation appears. Both of these materials are used in packaging in large volumes primarily because of their physical performance characteristics and low costs. They are thus found in utility goods packaging. Utility goods are highly competitive and price is usually closely related to actual production and distribution costs. In these applications, a tax would almost always be passed on to the consumer and would not act as a deterrent. For instance, metal cans and glass jars are used predominately in packaging of such utility goods as cooked vegetables, fruits, soups, and other like staples. In the case of these commodities, the profit margin on the end-product is low. A tax on the basic container material would almost certainly seriously affect profitability of the product. In such a case, the additional cost would be passed on as an alternative to selling the utility goods at cost.

A tax on metal cans would have different effects depending on what is taxed. A general tax would probably have no effect. If it is levied only on tin-plated steel cans in order to bring about a switch to tin-free steel, it would probably accelerate commercialization of such a container. A tax on aluminum cans could result in a switch to steel if the tax is high enough; aluminum and steel cans compete for beverage markets on the basis of cost, performance, and consumer preference. If the tax is nominal, aluminum manufacturers would most likely absorb it. A tax on aerosol dispensers would almost certainly be passed on to the consumer—who chooses the more expensive aerosol form of a product because of its convenience, not its price.

A tax on wooden containers would have to be rather substantial to have an effect. Wooden pallets and skids, kegs, and boxes are used principally because their costs are low in comparison with metal. It might also cause a shift to corrugated containers which would mean an increase in the total waste load; wooden containers are reused typically; corrugated containers tend, on the whole, to make only a single trip. Taxation of paper and textile packaging to reduce its use would be less meaningful because these materials are the most disposable of all packaging materials and constitute about 50 percent of total packaging tonnage. We do not believe that a tax on paper would result in the reduction of the quantity of packaging wastes generated; it would merely increase the costs of packaging.

In order to use a deterrent tax as an instrument for influencing packaging, we would recommend that detailed systems analysis of effects, not only on materials or container consumption but also in inter-materials competition, be undertaken. Such analysis would only be warranted, however, if some assurance could be gained that the deterrent tax route to control would meet with legislative success, which does not appear very likely.

Regulation

Within the context of this report, regulation means any legislative measure enforced by the executive arm of the government, which imposes some action on package materials producers, converters, and packagers and/or users (consumers) The action imposed must be involuntary in nature, which contrasts with incentives and disincentives; these latter leave those affected a margin of choice. Mechanisms of the more voluntary type are discussed separately.

Regulations may be imposed by governments at all levels. The focus of this analysis, however, is on federal regulation since this report deals with packaging and waste disposal on a national basis.

Government regulation in the sense used here can mean a variety of things: the establishment of standards, the control of production through quotas, the prevention of unfair trade practices, quality monitoring, or full scale regulation of industry as practiced in air, land, and water transport by the Civil Aeronautics Board, Interstate Commerce Commission, and the Federal Maritime Commission, respectively.

The Nature of Current Regulatory Activity

As part of this analysis, we reviewed the activities of numerous federal departments, agencies, and bureaus in an effort to discover the types of regulatory activities which are currently employed and the fundamental reasons used to justify them. We felt this to be an important step toward assessing the possibilities of successful regulatory activity in packaging. A summation of our findings is presented in Table 96. Excluded from the tabulation are those agencies primarily engaged in regulating labor, manpower, and wage questions. Although these latter activities impinge upon industrial practices, they are not strictly concerned with commodities.

In the course of this review of department and agency regulatory or quasi-regulatory activities, we did not encounter any instances of regulation aimed at the correction of external diseconomies such as those created by packaging materials in waste disposal. The nearest analogy to such a situation is water pollution; the polluted discharges from one plant or facility create diseconomies for other operators downstream and for people wishing to use water bodies for recreation. The Department of the Interior has authority to abate such pollution in certain instances. However, it is possible to justify such abatement powers on the grounds that water pollution creates health hazards.

There are other instances where the government has been granted regulatory power over commodities or industries. Some control over the production, grading, labeling, and marketing of agricultural products is exercised by the Department of Agriculture, for example. The sale of securities is regulated by the Securities and Exchange Commission. The Food and Drug Administration of the Department of Health, Education, and Welfare controls the purity and

TABLE 96.—*Major Federal Government departments and agencies with regulatory functions and principal justifications for their activities* [a]

Department or agency	Basic principle for use of regulatory power						
	Protection health and safety	Consumer protection	Maint. of a free economy	Conservation of resources	Support of vital industries	Maint. of nation's defense posture	Control of public service utilities
Department of Justice: Antitrust division		X	X				
Department of the Interior: Office of Oil and Gas				X			
Bureau of Commercial Fisheries				X	X		
Bureau of Mines	X			X		X	
Federal Water Pollution Control Administration	X	X					
Department of Agriculture: Agricultural Stabilization and Conservation Service				X	X		
Consumer and Marketing Service	X	X	X				
Commodity Exchange Authority	X	X	X				
Department of Commerce: Business and Defense Services Administration			X		X	X	
Maritime Administration						X	
Department of Health, Education, and Welfare: Public Health Service	X						
Food and Drug Administration	X	X					
Department of Transportation: Federal Aviation Department	X					X	
Atomic Energy Commission	X			X	X	X	
Civil Aeronautics Board	X	X				X	X
Federal Communications Commission				X	X	X	X
Federal Deposit Insurance Corporation		X					
Federal Maritime Commission		X	X		X	X	X
Federal Power Commission					X	X	X
Federal Trade Commission	X	X	X				
Interstate Commerce Commission	X				X	X	X
Securities Exchange Commission		X	X				
Small Business Administration			X				

[a] Excluded are all departments and agencies dealing with questions of labor.

Source: General Services Administration, National Archives and Records Service, Office of the Federal Register, *United States Government Organization Manual 1967–68.* Washington. D.C., 1967.

labeling of pharmaceuticals, foods, and materials of packaging used in food. The Federal Trade Commission regulates the quality of fabrics shipped in interstate trade to prevent the sale of flammable materials in apparel applications. And government control of certain public service industries—transportation, communications, and power generation—is practiced.

In all of these instances and others that might be cited, intervention is justified on the grounds that regulation will result in health, safety, or consumer protection; the maintenance of a free but fair economic system; the conservation of important natural resources, the support of industries vital to the national welfare; maintenance of the nation's defense posture; the control of monopolies or semi-monopolies such as power generation and communications; and control of industries closely linked to defense preparedness like air, water, and land transportation.

Regulation in Packaging

The above situation would seem to indicate that any regulatory activity directed at packaging would have to be based on new concepts of control, not on precedent. Three exceptions to this general statement exist. One would be regulatory activity whose purpose is conservation of natural resources; the second, control of packaging materials which create a potential health hazard; the third, consumer protection. Government action is not unfamiliar to the packaging industry and packagers as may be seen in Table 97. In fact the industry is in the midst of trying to

TABLE 97.—Federal Packaging Regulations and the Agencies That Enforce Them

Federal enforcement agencies	Products covered by packaging and labeling regulations				Code of federal regulations	
	Foods, including meat, poultry, & soft drinks	Alcoholic products & tobacco	Drugs & cosmetics	Chemicals & related products	Title number	Act and date
Department of Agriculture	Meat, meat products.				9	Meat Inspection Act, 1906.
Consumer & Marketing Service.	Poultry, poultry products.				7	Poultry Products Inspection, 1957.
Agriculture Research Service				Pesticides.	7 7	Standard Container Acts, 1916, 1928. Insecticide, Fungicide, Rodenticide Acts.
			Biologics for animals.		9	Virus-Serum-Toxin Act, 1913.
Federal Aviation Agency				Dangerous articles.	14	Aviation Regulations, Part 103; Transportation of Dangerous Articles, etc.
Department of Health, Education, & Welfare.	Foods, including pet unless otherwise stated.	Alcohol in drug products.	Drug cosmetics.	Food additives.	21	Food, Drug, Cosmetic Act, 1938 (with amendments, including Food Additives Amendment, 1958).
	Enforces regulations designed to prevent deceptive and unfair trade practices, including deceptive packaging and labeling.					Fair Packaging and Labeling Act, 1966.
Food & Drug Administration				Hazardous substances.	21	Hazardous Substances Labeling Act, 1960; Caustic Poison Act, 1921; Child Protection Act, 1966.
Treasury Department		Alcoholic, beverages, tobacco.			26 27	Internal Revenue Code Alcohol Administration Act.
Alcohol and Tobacco Tax Division.			Products with denatured spirits.			
		Industrial spirits.				
Bureau of Narcotics			Narcotics.		26	Internal Revenue Code.
Coast Guard				Dangerous articles.	46	Dangerous Cargo Act, 1940.
Bureau of Customs	Enforces various regulations regarding imports.				19	Tariff Act, 1930 (as amended).
Federal Trade Commission	Enforces regulations designed to prevent deceptive and unfair trade practices, including deceptive packaging and labeling.				16	FTC Act, 1914; Wool Products Labeling Act, 1939; Textile Fibre Products Identification Act, 1951; Fur Products Labeling Act, 1951; Fair Packaging and Labeling Act, 1966.
Interstate Commerce Commission				Dangerous articles.	49	Transportation, Parts 71–90—Explosives and the like; Part 78—Containers.
Post Office Department	Enforces various regulations regarding postal shipments.				39	The Postal Service Act of September 2, 1960.

Source: *Modern Packaging Encyclopedia.* William C. Simms, ed. Vol. 40, No. 13A. New York, McGraw-Hill, Inc., September 1967. 879 p.

assimilate the 1966 Fair Packaging and Labeling Act after a lengthy battle of several years' duration. However, all regulatory activity cited is aimed at the prevention of commercial abuses and the promotion of health and safety, or it deals with international trade on high-tax commodities like alcohol.

Control based on conservation of resources may be employed to reduce the quantity of paper wasted. According to Forest Service and industry forecasts, by the end of the century U.S. capacity to produce pulpwood may be seriously strained if current domestic consumption and pulp export trends continue. This view, incidentally, is not shared by all companies in the paper industry. Since the bulk of our aluminum (80 percent) is imported, squandering of this material is a contribution to the gold drain. Domestic shortages in ferrous metals and hydrocarbons are less likely to occur in the foreseeable future.

Only one packaging material—polyvinyl chloride—may be seen as a substance which is potentially hazardous. Since this material represents a small fraction of total plastics used in packaging—and plastics are a small percentage of packaging—the impacts on total waste generation of controlling polyvinyl chloride would be negligible.*

Authority to regulate packaging, based on the justification that these materials create an economic burden for waste disposal system operators, would be extremely difficult to realize. The chief reason for this is that the waste generators—householders, business operators, institutional managers—must logically pay the costs of disposal. It may be asked: Why cannot the waste generator be made to pay a sufficiently high amount for waste disposal services to cover all expenses? After all, it is their wastes which must be handled. If the packaging industries are held responsible for the added costs of disposal, a situation is created which would be analogous to holding a wheat farmer responsible for flour dust emanating from a grain mill.

A second reason why it would be difficult to obtain regulatory authority is the fact that regulation, once begun, would tend to be complete. The basic reasons for this contention are the complexity of packaging and the fact that packages fulfill intangible, difficult-to-measure services. A package may be likened to an intricately woven fabric whose strands are made of tangible qualities (physical performance) as well as more intangible qualities (shape, appearance, "convenience," etc.). It is not possible to unravel this fabric without destroying it. Consequently, it would be difficult to promulgate *effective* regulations without eventually controlling all aspects of packaging. Since packaging touches all economic activities in some way, the regulation of packaging would consequently involve exercise of some degree of control of merchandising, product design, etc.

We do not mean to imply that all forms of regulation would have this effect, only that truly effective regulation would require such an extreme step. This will become clearer as we examine three hypothetical cases of regulation: (1) regulation of the quantity of materials to be used in packaging; (2) regulation of materials to reduce difficulty in processing; and (3) regulation of certain container types.

Case 1: Regulation of Quantity

In this case regulation would focus on restricting the *amount* of materials which may be used, with the aim of reducing the quantity of packaging materials which end up in trash barrels.

The basic difficulty here would be that of establishing meaningful criteria of measurement. Neither in terms of quantity nor in terms of values is there a uniform relationship between package and product. A package may weigh many times more than the product (aspirin bottle) or much less (wooden pallet carrying machinery). In terms of value, the package may be an insignificant percentage of the product's value (cardboard box housing a television set) or the most expensive component of the product (hair spray can) Table 98.

In such a situation, broad standards would be meaningless, and a regulating agency would have to immerse itself into a morass of detailed judgements which would have to be made about each commodity and each package configuration used for each commodity.

---

*PVC is used at the rate of over 2 billion pounds per year for manufactured products such as garden hoses, floor coverings, rain wear, shoe soles, construction materials, etc., and so could be a larger factor in total solid waste today than the relatively small volume likely to be used in packaging in future years.

TABLE 98.—*Package costs of selected products*

As a percentage of product sales price, f.o.b. factory

Product and packages	Percent [a]
Paint in an aerosol can	16
Paint in a conventional metal can	5
Toy in a film-overwrapped carton	14
Toy in a blister pack	8
Motor oil in a metal can	26
Motor oil in a fiber can	10
Small appliance in a corrugated carton	6
T.V. set in a corrugated carton	1
Beer in a tinplate can	43
Beer in a one-way glass bottle	36
Frozen food in a boil-in-bag and carton	10
Frozen fish in a carton	5
Moist pet food in a metal can	17
Dry pet food in a carton	9
Cereal in a folding carton	15
Cornmeal in a paper bag	5
Analgesic in a plastic bottle	10
Antibiotic in a plastic bottle	1
Baby food in a glass jar	36
Baby juice in a metal can	33

[a] The figures above are not presented as averages. In any given product field, the cost ratio may vary widely even among the same size packages made of the same materials.

Source: *Modern Packaging*, 40(9): 93, May 1967.

Such regulation, carried to a logical conclusion, would also involve the government in packaging and merchandising decisions which are presently the exclusive domain of industry. Should or should not a soap bubble bottle be in the form of Mickey Mouse? If the decision is no, less material may be used, but the product may not be as easy to sell. Should or should not a fountain pen be encased in plastic and mounted on a display board? Should dolls be displayed in cartons faced with cellophane on one side? Or, conversely, displayed without wrapping? Such decisions would have to be made routinely in order to achieve the objectives of regulation. The reverberations of this type of activity would be felt throughout U.S. industry and commerce.

Although it would be difficult to predict the costs of such a program, it would appear that the administrative expenses both on the government and industry side would be better spent in the form of subsidies to waste disposal agencies.

Case 2: Regulation of Materials

Regulation, in this case, would focus on reducing the difficulty of processing packaging wastes by either outlawing highly resistant materials or requiring that certain types of materials not be used as components of specific packages. This type of activity can be much more selective, and consequently less disruptive, than regulation of the quantity of materials that would be permitted in packaging. Nevertheless, the regulatory body would be forced to deal with problems which are currently solved by the operation of market forces.

It should be noted at the outset that prohibition of material types would necessarily upset the "materials balance" in packaging. Careful studies of the effects of any specific prohibition would have to be made to forecast the likely responses and to evaluate the waste disposal implications of such responses. For example, prohibition of glass would undoubtedly create a vast market for metals and plastics. If plastics should capture a large share of glass markets, new plastic production facilities would be built, plastics prices might fall further, making these materials more competitive with paper. As plastics begin to displace paper, disposability of packaging materials would deteriorate. It is, therefore, highly conceivable that further regulation, aimed this time at plastics, would have to be passed to remove the ultimately adverse effects of a ban on glass. Such regulation could, in turn, have yet other undesirable effects. In this case also, control of one part of the packaging industry would seem to lead perforce to control of all activities.

If regulatory action takes the form of more specific prohibitions, the danger of creating large disruptions diminishes, but effectiveness of regulation also suffers. It would be possible, for instance, to require that tin be eliminated from steel cans; that twist-off bottle caps which leave a ring of aluminum adhering to the bottle neck be replaced with other closures; that paper be coated and imprinted with materials which are easily removable by a specific de-inking process; that aluminum cans be made of a single alloy; etc. All such requirements would aid salvage and reuse; they would not have an effect on disposal difficulty in incinerators, landfills, and composting plants. Justification for such moves could be made on the grounds of conservation, particularly if adequate means of separating and collecting these materials are created simultaneously and the use of such materials is promoted in industry.

Requirements which specify material characteristics would also be covered by this case. One such requirement might be that all packaging materials be biodegradable. This would in effect be a prohibition of metals and glass—assuming, for the moment, that biodegradable plastics could eventually be developed. If such a requirement is imposed only on one or two materials, for instance, paper and plastics, the requirement would be difficult to justify. Similar difficulties would be encountered in the promulgation of other material characteristic specifications that could be envisioned, for instance, combustibility, compaction under pressure, etc.

Thus it would appear that regulation of materials is only feasible in a very limited sense to bring about more salvable and reusable packages, but that other requirements would either lead to complete control of packaging or would be extremely difficult to realize in practice.

Case 3: Regulation of Container Types

Regulation of container types would be similar to the regulation of materials. The most frequently proposed regulation of this type is a ban on nonreturnable beverage containers. Legislation of this type was proposed in 19 states in 1967; altogether, 32 proposed laws were presented; none passed (Table 99). All of these laws were proposed as

TABLE 99.—*1967 container-litter legislative bills introduced* [a]

State	Bill number	Purpose of bill
Alabama	H.653	Ban on nonreturnable bottles.
Connecticut	S.1157	Bans nonreturnable beverage bottles and cans of aluminum.
Kansas	A.1326	1¢ tax on no-deposit containers.
Maine	H.892	Bans nonreturnable bottles.
Massachusetts	H.2893	Bans use of nonreturnable bottles.
	H.3033	Mandatory deposit on all bottles and cans.
Michigan	H.1158	Both bans on nonreturnable containers.
	H.2024	
	H.2416	Requires 5¢ deposit on nonreturnable bottles.
	H.2556	Prohibits sale of beer in nonreturnable bottles.
	H.3248	Bans nonreturnable bottles.
	S.8	Bans nonreturnable bottles.
	S.153	Requires bridges be fenced to prohibit littering and dumping of objects onto highway.
Minnesota	H.920	Bans nonreturnable bottles.
	H.1218	Bans sale of beverages in cans of more than 10% aluminum.
	H.2127	Requires 3¢ deposit on cans and bottles.
	H.2575	Bans bottles on lakes and public beaches.
	S.560	Requires 3¢ deposit on bottles and cans.
	S.1019	Bans use of cans of more than 10% aluminum.
Missouri	H.552	Provides for 1¢ tax on cans and nonreturnable bottles.
	H.553	Bans nonreturnable bottles.
Montana	H.462	Requires 1¢ deposit on all cans and nonreturnable bottles.
Nebraska	LB.281	Requires 1¢ deposit on all beer cans and bottles.
New Hampshire	H.677	Bans sale of malt beverages and soft drinks in other than returnable containers.
New Mexico	H.215	Requires 4¢ deposit on cans and bottles.
New York	S.4190	Tax of 1 mil on nonreturnable containers; 2 mils on such containers with self-opening devices.
North Dakota	S.146	Deposit required on all cans and bottles.
Oklahoma	H.514	Bans sales of bottled soft drinks on Capitol grounds.
Pennsylvania	S.1147	Prohibits use of nonreturnable bottles.
South Dakota	H.507	Bans beer in cans and nonreturnable bottles.
Washington	H.131	Requires 2¢ deposit on all bottles for soft drinks and beer.
Wisconsin	A.559	Requires offer of 1¢ redemption on labels of beer cans and bottles.
	A.636	Bans sale of beverages in nonreturnable bottles.

[a] None of these proposed laws was enacted.

Source: John E. Evans. Litter Legislation in 1967. Courtesy of Keep America Beautiful, Inc.

instruments to curb litter. Let us examine this situation in a little more detail.

Legislation aimed at nonreturnable type containers, to be effective in reducing litter or in promoting the use of reusable containers, must have several characteristics: (1) it must prohibit the use of *all* nonreturnable container types currently used for a certain commodity; (2) it must impose a sufficiently high deposit so that the consumer is impelled to return the container; (3) it must provide for the ban of new container types which may appear in response to the prohibition, e.g., plastic bottles; and (4) it must anticipate problems of definition; thus it should define a beverage container as any type of container, by whatever name it may be called, so that beverage "jugs," "jars," "tubs," etc., cannot be sold in violation of the spirit of the law.

Probably the most important point above is a high deposit. It may be possible to require that all beverage containers be returnable, but it is not possible to force an affluent population to return such bottles without sufficient incentives. Legislation which permits one kind of no-deposit container but bans another serves only to boost the sale of the exempted container.

The real effectiveness of such regulation to reduce litter may be questioned. In the State of Vermont, where such legislation was passed, the ban on bottles did not measurably reduce the costs of litter collection; consequently, the ban was repealed after one year of enforcement (1955–1956).[9] Taxes imposed on those container types most frequently encountered along our highways and streets would probably be more effective if such tax receipts were used to clean up litter. This is the apparent intent of some of the proposed laws shown in Table 99. But whereas total litter may not be reduced, such legislation may be used effectively, in combination with other steps, to keep substantial amounts of packaging out of the waste stream.

A nation-wide law which would (1) ban nonreturnable glass beverage containers, (2) impose a high deposit on metal beverage cans, (3) require that the retailers accept and segregate empty aluminum and steel cans, and (4) prohibit the use of tin in steel beverage containers could result in the recycling of much glass, aluminum, and steel if local waste disposal agencies, scrap dealers, and scrap users coöperate.

Major problems of such an action, aside from problems of justification, would be (1) that retailers would be saddled with an additional materials handling chore, whose costs would have to be passed on to the consumer in some form; (2) empty beverage containers would produce unpleasant odors and would have to be stored in a special place; (3) in many smaller communities, aluminum and steel would be available in quantities too small to justify collection; and (4) cooperation from waste disposal agencies and scrap collectors may not be forthcoming.

It is clear from the foregoing that regulation of containers, even in a relatively narrow area like beverages, could give rise to some vexing problems of implementation. Such problems would increase in number many times if regulation is extended into other areas.

Summary

Regulation of packaging to achieve objectives set forth earlier does not appear to be a practical approach for two reasons.

(1) It would be unlikely to meet with legislative approval because sufficient justification does not exist for government intervention.

(2) The administrative chore of carrying out effective regulation would be disproportionately greater than the benefits which could be envisioned because packaging is a very complex activity and would consequently require government action on too many fronts.

Another reason, which was developed earlier, is that one of the objectives which could be achieved by regulation—modification of materials to improve their salvability—appears easier to achieve by less direct action incentive or subsidy.

BARRIERS TO ACTION

General

In the foregoing analysis, numerous barriers to effective action on the part of the federal government were mentioned or implied. In this concluding section, we should like to discuss these barriers in somewhat more detail to characterize their nature.

Barriers to action are identifiable forces which, together, form the environment in which packaging exists and tend to make change difficult. No single barrier, taken by itself, would be sufficient to seriously block action. Taken together, however, the cultural, demographic, socioeconomic, and techno-economic factors discussed here are a formidable obstacle in the path of many of the approaches to mitigating disposal problems arising from packaging.

One general barrier, implicit in all that has been said in this and earlier sections of the report, is the fact that all those forces which promote the continuing evolution of packaging in presently established directions are forces antithetical to the best interests of waste disposal and salvage operators. Since Public Health Service objectives with regard to packaging are formulated to aid waste handling, those basic movements which make packaging what it is may be viewed as barriers.

A summary of the barriers, to be discussed here, is presented in Table 100. It shows the barriers and their relationships to the three basic objectives outlined at the outset. We have made an attempt, in the tabulation, to indicate the relative importance we attach to each barrier vis-a-vis each objective.

Table 100.—*Importance of barriers to waste reduction objectives*

Barriers	Waste reduction objectives		
	Reduce quantity of packaging in waste	Reduce technical difficulty	Conserve natural resources
Techno-economic:			
Large number of materials	2	4	5
Production technology	3	2	5
Socioeconomic:			
Pervasive nature of packaging	3	3	1
Self-service merchandising	3	2	3
Cultural: Free enterprise philosophy	5	5	4
Demographic:			
Population growth	4	1	2
Affluence	4	3	4
Desire for convenience	3	3	4

Code: 1—Negligible barrier.
2—Minor barrier.
3—Moderately important barrier.
4—Important barrier.
5—Very important barrier.

Source: Midwest Research Institute.

Techno-Economic Barriers

Techno-economic barriers consist in the large number and interchangeability of packaging materials and their combinations which make any regulation based on material or configurational characteristics difficult; and in the highly developed state of raw materials conversion technology, which has a depressing effect on the consumption of secondary materials, as was discussed in Part II of this report.

To meet with legislative approval, proposed regulatory action in packaging has to be justified and must have some chance of succeeding in practice. Blanket-type regulation, e.g., a complete ban on nonreturnable glass containers, is unlikely to accomplish the desired aim of reducing packaging waste generation because substitutes for glass exist, all of which would be discardable and would cause just as much difficulty in disposal as the container banned.

More specific legislation would be difficult to write and enforce. For purposes of illustration, let us consider only one commodity, milk, and its packaging. For instance, if plastic coatings are prohibited on milk cartons, the industry may counter by using hot-melt coatings. Since these are part plastic and part wax, legislation would have to specify exactly what percentage of plastics would be permissible; the line may have to be drawn between synthetic and natural resins, etc. If the legislation would not simultaneously outlaw plastic bottles, these may take over part of milk packaging. If plastic bottles are outlawed but plastic coated paper is permitted, the legislation would have to be specific as to the ratios of plastic to paper that would be permitted, or else a situation may arise where a few paper fibers, embedded in plastic, would be sold as plastic-"coated" paper. If plastic coatings *and* plastic bottles *and* hot-melt coatings were all prohibited, this would probably *not* bring a return to wax-coated milk cartons; these have irritated the consumer for years. Rather, nonreturnable glass containers may make their appearance.

This illustration, based on a single commodity, is sufficient to show that the problems of regulation would be quite serious when extended to all products, mainly because there are many materials, comparable in cost, among which the packager can choose, and many ways in which he can combine them.

The highly developed technology of converting raw materials into packaging is a barrier to actions designed to promote salvage and reuse. Production technology in packaging has evolved around raw-material resources. Much of the packaging industries' production, marketing, and acquisition activities reflects this raw materials orientation.

To promote the use of secondary materials, it is necessary to reorient user industries from a virgin materials focus to a secondary materials focus. Understandable resistance to such efforts can be anticipated since heavy investments in plant, equipment, and land have been and are being made to process virgin stocks. In the glass and paper industries, also, plants have been located with reference to raw materials sources, not with reference to secondary materials generation points. Secondary materials thus suffer from locational drawbacks along with having technological demerits.

In addition to the two techno-economic barriers discussed, there are others which have already been covered in earlier parts of this report, specifically the "contamination" of packaging wastes, the low price of secondary materials, and the trends toward package type multiplication and continued proliferation of exotic material marriages.

Socioeconomic Barriers

Perhaps the most important socio-economic fact, which acts as a barrier to the control of packaging, is the pervasive nature of this activity in U.S. economic affairs. Packaging touches virtually all aspects of our economic life.

Since packaging reaches into all areas of distribution—barring only shipment of certain bulk commodities—it is difficult to intervene in one area of packaging without disrupting one or more others, thereby possibly creating new disposal problems and necessitating further control. If, for instance, plastic coatings and all-plastic containers were to be outlawed, a variety of products now packaged in paper may appear in the market place in glass, metal, metal-coated paper containers or using more durable coatings than plastics. Certain product configurations would disappear, e.g., translucent, pliable shampoo tubings. Heavy investments in plastic extrusion, shrink-wrapping, blow-molding, and other machinery would be idled. Merchandising practices would undergo a transformation as film-wrapped products would be eliminated, and millions would be spent redesigning satisfactory existing packages. Plastics prices would drop precipitously as idle capacity would be created. Certain firms would be forced out of business or into new ventures. Similar effects would result from any other, or any degree, of regulation.

What the complexity of packaging means, in effect, is that it is difficult to predict the results of intervention with any degree of accuracy. Consequently, a great deal of money would have to be spent to prepare studies in adequate depth and detail to be used as justification for legislative action whose outcome would be doubtful. When such activity is viewed in the light of the percentage of total waste that packaging represents, control of packaging may appear the most costly and least practical of several alternatives.

A second socioeconomic barrier is the intimate relationship between packaging and self-service merchandising. Packaging in its modern form is largely a response to the needs of such merchandising. Packaging provides the ingredients of display, demonstration, communication, and salesmanship which are missing in stores with a minimum of clerks. It also supports innovative new product merchandising by providing adequate protection for new types of food and chemical products.

Any serious attempt to reduce the absolute quantity of packaging used and to improve the salvability or disposability of containers will necessarily interfere with the free and natural selection of materials for packaging. A regulatory agency could not take into consideration—because it could not measure—the intangible qualities that containers give to products on sale. Consequently, regulatory measures would necessarily have to disregard a vital packaging function, communication.

Self-service merchandising also implies convenience to the consumer, a lower selling cost to the merchant by reason of lower labor inputs, and consequently lower prices. Regulated changes in packaging may reduce package costs by reducing packaging material use, but they may ultimately cause an upward shift of product price by indirectly increasing selling costs. This would be an undesirable result of regulatory change, which would have to be justified by corresponding savings in disposal. Neither price deteriorations nor savings in disposal, however, appear to be predictable.

Cultural Barriers

The United States is the home of a voluntaristic society based on the concept of free enterprise action in the economic sphere. This is, perhaps, the fundamental difficulty as concerns government action aimed at packaging.

The role of government, in our society, has been essentially passive in the economic realm—passive certainly in comparison with the roles played by governments in less voluntaristic societies.

Government regulation of commerce has been restricted largely to consumer protection from health and safety hazards and deceptive practices, the protection of free competition, and the like. With the exception of minimum wage laws and wartime legislation, the Federal Government has not intervened to regulate industry in order to eliminate diseconomies except where the health and safety of the population were threatened. Air pollution legislation is an example of intervention justified by health threats.

On the other hand, government does engage and is presently active in the development of new technology, either directly or by subsidy, on the grounds that the private sector either cannot or will not develop a particular, desirable technology. Defense-related developments fall into this category, but such activities as research and demonstration work in desalination, educational television, and the development of a supersonic commercial aircraft are not strictly linked with maintenance of the nation's military posture. Public Health Service grants to municipalities for the demonstration of new disposal technology are yet another example of government support of new developments.

While these latter activities exist, we do not find any instance of government regulation of industry aimed at easing the *economic* plight of a private group *external* to the industry being regulated. Regulation of packaging to assist waste disposal agencies is precisely such a situation.

We emphasize the words "economic" and "external." Minimum wage legislation is an example of legislation aimed at the betterment of the economic conditions of wage earners within industry. Air pollution control regulations benefit groups external to an industry, but their justification is not in the economic but in the health sphere.

Demographic Barriers

In the sense that there will be a need for more products to feed, clothe, shelter, and entertain a growing population, packaging will grow; and thus population increase is a basic barrier to any effort at reducing the quantity of packaging materials which will enter the waste stream.

Equally important are other trends which may be classed as either demographic, cultural, or socio-economic, but which we include here. Two of these are growing affluence and more leisure (Tables 101 and 102).

TABLE 101.—*Index of disposable personal income and per capita personal consumption expenditures on selected items* [a]

[1960=100]

	1960	1961	1962	1963	1964	1965	1966
Disposable personal income/family	100	103	107	111	119	127	136
Per capita personal consumption expenditures:							
Jewelry and watches	100	101	108	114	126	135	157
Recreation	100	107	112	121	134	144	157
Foreign travel	100	101	110	123	129	144	155
Religious and welfare activities	100	102	104	106	112	116	125

[a] Based on current dollars.
Ibid. Survey of Current Business, 47(7), July 1967.

Source: U.S. Department of Commerce, Office of Business Economics. *The National Income and Product Accounts of the United States, 1929–1965*. Washington, D.C., 1966. U.S. Department of Commerce, Bureau of the Census. *Current Population Reports*. Series P–25, No. 372. Washington, D.C., 1967. Midwest Research Institute.

TABLE 102.—*Estimates of average work week and length of vacation per year by major occupational groups: 1960 and 1976*

Major occupational group	1960		1976	
	Hours worked per week	Average vacation per year (length in weeks)	Hours worked per week	Average vacation per year (length in weeks)
Professional	38. 5	2. 8	35. 5	3. 8
Managers, officials, and proprietors	47. 4	2. 9	43. 8	3. 2
Clerical workers	36. 0	2. 0	33. 0	3. 0
Sales workers	36. 6	1. 7	33. 6	2. 5
Craftsmen	38. 9	2. 1	35. 9	2. 8
Operatives	38. 2	1. 9	35. 0	2. 4
Service workers	35. 0	1. 3	31. 0	2. 4
Farmers	44. 5	. 7	41. 0	. 8
Laborers	34. 2	1. 4	31. 4	2. 2
Total, all groups	38. 5	2. 0	35. 4	2. 8

Source: Outdoor Recreation Resources Review Commission, *Projections to the Years 1976 and 2000: Economic Growth, Populations, Labor Force, and Leisure and Transportation*. ORRRC Report 23. Washington, D.C., 1962. p. 59, 72.

These forces at work in our economy to bring a higher living standard combine to support a growth in packaging by supplying the wherewithal to purchase goods, by creating a demand for convenience, by removing the need for thrift and the motives for salvage, and by creating resistance to unpleasant chores and disciplines which are perceived as unnecessary, e.g., separating waste components, compacting of wastes, returning deposit-type bottle, and the like.

Such attitudes are barriers to government action in that popular support of regulation cannot be expected to materialize.

Recommendations

On the basis of the above evaluation of mechanisms, it is recommended that the Public Health Service:

(1) Undertake a comprehensive analysis of the secondary materials industries as a preliminary step to the formulation of a policy and program which will result in increased use of waste materials by industry. Such analysis would define, among other things, the technological requirements and economic conditions necessary to increase waste materials use.

(2) Formulate policies and develop a funding program to support industrial, association, and/or public (federal, state, or local) development and construction of devices and systems for the preparation, handling, and processing of secondary materials.

(3) Initiate programs in conjunction with industry and/or industry associations to encourage the adoption of materials acceptable for reuse.

(4) Take the initiative in the development of an automated waste separation process. First step in this direction would be an investigation of the state of the art of sensing instrumentation.

(5) Plan and conduct meetings on various levels which would involve packaging executives, designers, engineers, materials producers, and associations from industry; and local and state waste disposal agency operators. The objectives would be to establish a useful forum for information exchange, to familiarize each group with the problems of the other, and to stimulate useful exploration of actions that each may take.

(6) Establish a Solid Waste Technology Information Center either on a free or subscription basis, aimed at State and local disposal agencies, waste handling equipment makers and process designers, and other organizations exploring or interested in new or advanced methods of waste handling. Such a Center could be built on the basis of the Solid Waste Information Retrieval System (SWIRS) now under development by the Office of Information of the Bureau of Solid Waste Management.

(7) Cooperate with private groups in the development of consumer and industrial educational programs to increase awareness of the dimensions of solid waste generation and handling. These could be in the form of informative publications, use of audio-visual and other media, and would include furnishing information about availability of such programs.

(8) Form an interagency task force or study group involving the staffs of other federal agencies which have an influence on packaging to familiarize them with the Bureau of Solid Waste Management mission; and to establish design criteria or specifications aimed at more acceptable packaging from a solid waste viewpoint. A part of this would include use of federal purchasing criteria to bring about desirable changes in packaging of products purchased by and for federal agencies.

(9) Conduct or support a study to determine the feasibility, desirability, and necessity of a packaging use tax on the basis of "disposal resistance" as developed in this report.

REFERENCES

1. Question accuracy of APWA solid waste report. *Refuse Removal Journal*, 10(9): 20 Oct. 1966.
2. *Ibid.*, and interview, Mr. George Walsh, editor, *Refuse Removal Journal*, 11: ( ) Oct. 1967.
3. Report of the Vermont State Litter Commission, State of Vermont, Dec. 15, 1956. p. 6.
4. Weststrate, W. A. G. Comments. *In* Wiley, J. S. A discussion of composting of refuse with sewage sludge. *Compost Science*, 8(1): 24–25, Spring-Summer 1967.
5. Charles H. Lipsett. *Industrial wastes and salvage.* The Atlas Publishing Company, New York, 1963. p. 58.
6. W. S. Story. Problems of the salvage industry as they relate to solid waste disposal. In *Proceedings, National Conference on Solid Waste Research*, American Public Works Association, Chicago, Illinois, December 1963. p. 162.
7. A. T. Luey. TAPPI programs and paper stock. *Fibre Market News*, 10(60): 6, Section II, October 19, 1967.
8. Charles H. Lipsett. *Op. cit.* p. 7.
9. Vermont State Litter Commission. *Op. cit.*

APPENDIX I

The Disposability of Packaging Materials

Preceding page blank

TABLE 103.—*Calculation of disposal resistance index: 1976* [a]

Material	Tonnage share	Incineration 0.18		Sanitary landfill 0.13		Open dumping 0.64		Composting 0.01		Salvage 0.04		Total 1.00
		Value	Index	Value	Index	Value	Index	Value	Index	Value	Index	
Paper and paperboard	0. 5686	150	15. 352	170	12. 566	100	36. 390	230	1. 308	200	4. 549	70. 165
Metals	. 1296	480	11. 197	160	2. 696	100	8. 294	460	. 596	240	1. 244	24. 027
Glass	. 1832	490	16. 158	160	3. 811	100	11. 724	360	. 660	250	1. 832	34. 185
Wood	. 0681	210	2. 574	270	2. 390	100	4. 358	180	. 123	450	1. 226	10. 671
Plastics	. 0482	310	2. 690	290	1. 817	100	3. 084	480	. 231	330	. 636	8. 458
Textiles	. 0023	190	. 079	120	. 036	100	. 147	180	. 004	250	. 023	. 289
Total	1. 0000	......	48. 050	......	23. 316	......	63. 997	......	2. 922	......	9. 510	147. 795

[a] Material market share times process share times value=index.

Source: Midwest Research Institute.

Preceding page blank

TABLE 104.—*Disposability ratings: Paper and paperboard*

Product	Sanitary landfill			Incineration					Composting		Salvage	
	Density 0.05	Compactibility 0.80	Degradability 0.15	Burning rate 0.75	Inert solids 0.15	Btu value 0.04	Sulfur content 0.01	Potential damage to equip. 0.05	Degradability 0.80	Suitability 0.20	Separability 0.25	Market for the commodity 0.75
Containerboard	300	200	200	100	200	400	300	100	300	100	300	100
Folding boxboard	400	100	100	200	100	400	300	100	200	100	300	200
Special foodboard	400	100	100	200	100	400	300	100	200	100	300	200
Set-up boxboard	400	100	100	200	100	400	300	100	200	100	300	200
Tube and can stock	400	200	200	200	200	400	300	100	300	100	400	200
Drum stock	400	300	200	300	200	400	300	300	300	200	400	200
Wrapping paper	400	100	100	200	100	400	300	100	200	100	300	200
Shipping sacks	400	100	100	200	100	400	300	100	200	100	300	200
Bag paper	400	100	100	200	100	400	300	100	200	100	300	200
Converting paper	400	100	100	100	100	400	300	100	200	100	300	200
Glassine, greaseproof	400	200	400	100	100	400	300	100	300	100	500	400
Coated printing paper	400	100	200	100	100	200	300	100	200	100	300	400
Book paper	400	100	100	100	100	200	300	100	300	100	300	400
Tissue paper	400	100	100	100	100	400	300	100	200	100	300	400
Pulp, pressed and molded	400	100	100	200	100	400	300	100	100	100	500	200

Source: Midwest Research Institute.

TABLE 105.—*Disposability resistance calculations: paper and paperboard, 1966*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
Containerboard	0.495	100.0	49.5	205.0	101.5	129.0	63.9	260.0	128.7	150.0	74.3
Folding boxboard	.144	100.0	14.4	115.0	16.6	189.0	27.2	180.0	25.9	225.0	32.4
Special foodboard	.076	100.0	7.6	115.0	8.7	189.0	14.4	180.0	13.7	225.0	17.1
Set-up boxboard	.022	100.0	2.2	115.0	2.5	189.0	4.2	180.0	4.0	225.0	5.0
Tube and can stock	.016	100.0	1.6	210.0	3.4	204.0	3.3	260.0	4.2	250.0	4.0
Drum stock	.005	100.0	.5	290.0	1.5	289.0	1.4	280.0	1.4	250.0	1.3
Wrapping paper	.025	100.0	2.5	115.0	2.9	189.0	4.7	180.0	4.5	225.0	5.6
Shipping sacks	.039	100.0	3.9	115.0	4.5	189.0	7.4	180.0	7.0	225.0	8.8
Bag paper	.067	100.0	6.7	115.0	7.7	189.0	12.7	180.0	12.1	225.0	15.1
Converting paper	.048	100.0	4.8	115.0	5.5	114.0	5.5	260.0	12.5	425.0	20.4
Glassine, greaseproof	.008	100.0	.8	240.0	1.9	114.0	.9	180.0	1.4	372.0	3.0
Coated printing paper	.015	100.0	1.5	130.0	2.0	106.0	1.6	260.0	3.9	372.0	5.6
Book paper	.021	100.0	2.1	115.0	2.4	106.0	2.2	100.0	3.8	372.0	9.8
Tissue paper	.009	100.0	.9	115.0	1.0	114.0	1.0	100.0	.9	275.0	2.5
Pulp, pressed and molded	.010	100.0	1.0	115.0	1.2	189.0	1.9	100.0	1.0	275.0	2.8
Total	1.000	....	100.0	....	163.3	....	152.3	....	225.0	....	205.7
Index number			100.0	....	160.0	....	150.0	....	230.0	....	210.0

[a] On the basis of tonnage share.

[b] Values calculated from Table 30 using the weighted average of factors used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

TABLE 106.—*Disposability resistance calculations: paper and paperboard, 1976*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
Containerboard	0.550	100.0	55.0	205.0	112.7	129.0	71.0	260.0	143.0	150.0	82.5
Folding boxboard	.129	100.0	12.9	115.0	14.8	189.0	24.4	180.0	23.2	225.0	29.0
Special foodboard	.083	100.0	8.3	115.0	9.5	189.0	15.7	180.0	14.9	225.0	18.7
Set-up boxboard	.013	100.0	1.3	115.0	1.5	189.0	2.5	180.0	2.3	225.0	2.9
Tube and can stock	.014	100.0	1.4	210.0	2.9	204.0	2.9	260.0	3.6	250.0	3.5
Drum stock	.004	100.0	.4	290.0	1.2	289.0	1.2	280.0	1.1	250.0	1.0
Wrapping paper	.021	100.0	2.1	115.0	2.4	89.0	4.0	180.0	3.8	225.0	4.7
Shipping sacks	.030	100.0	3.1	115.0	3.6	189.0	5.9	180.0	5.6	225.0	7.0
Bag paper	.073	100.0	7.3	115.0	8.4	189.0	13.8	180.0	13.1	225.0	16.4
Converting paper	.028	100.0	2.8	115.0	3.2	114.0	3.2	260.0	7.3	425.0	11.9
Glassine, greaseproof	.007	100.0	.7	240.0	1.7	114.0	.8	180.0	1.3	372.0	2.6
Coated printing paper	.016	100.0	1.5	130.0	2.1	106.0	1.7	260.0	4.2	372.0	6.0
Book paper	.019	100.0	1.9	115.0	2.2	106.0	2.0	180.0	3.4	372.0	7.1
Tissue paper	.005	100.0	.5	115.0	.6	114.0	.6	100.0	.5	275.0	1.4
Pulp, pressed and molded	.008	100.0	.8	115.0	.9	189.0	1.5	100.0	.8	275.0	2.2
Total	1.000	....	100.0	....	167.7	....	151.2	....	228.1	....	196.9
Index number			100.0	....	170.0	....	150.0	....	230.0	....	200.0

[a] On the basis of tonnage share.

[b] Values calculated from Table 30 using the weighted average of factor used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

TABLE 107.—*Disposability ratings: Metals*

Products	Sanitary Landfill			Incineration					Composting		Salvage	
	Density 0.05	Compactibility 0.80	Degradability 0.15	Burning rate 0.75	Inert solids 0.15	Btu value 0.04	Sulfur content 0.01	Potential damage to equip. 0.05	Degradability 0.80	Suitability 0.20	Separability 0.25	Market for the commodity 0.75
Steel cans	100	100	300	500	[illegible]	500	100	100	500	300	100	300
Aluminum cans and ends	100	100	400	500	[illegible]	500	100	300	500	300	400	200
Collapsible tubes	100	100	400	500	[illegible]	500	100	100	500	300	500	500
Rigid aluminum foil containers	100	100	400	500	500	500	100	300	500	400	400	200
Aluminum foil converted	100	100	400	500	500	500	100	100	500	400	400	400
Steel drums and pails	100	300	300	500	500	500	100	300	500	400	100	100
Metal strapping	100	400	300	500	500	500	100	300	500	400	100	100
Gas cylinders	100	500	300	500	500	500	100	500	500	400	100	500
Metal caps	100	100	300	500	500	500	100	100	500	300	500	500
Metal crowns	100	100	300	500	500	500	100	100	500	300	500	500

Source: Midwest Research Institute.

TABLE 108.—*Disposability resistance calculation: Metals, 1966*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
Steel cans	0. 723	100. 0	72. 3	130. 0	94. 0	476. 0	344. 1	460. 0	332. 6	250. 0	180. 8
Aluminum cans and ends	. 023	100. 0	2. 3	145. 0	3. 3	486. 0	11. 2	460. 0	10. 6	250. 0	5. 8
Collapsible tubes	. 002	100. 0	. 2	145. 0	. 3	476. 0	1. 0	460. 0	. 9	500. 0	1. 0
Rigid aluminum foil containers	. 006	100. 0	. 6	145. 0	. 9	486. 0	2. 9	480. 0	2. 9	250. 0	1. 5
Aluminum foil converted	. 019	100. 0	1. 9	145. 0	2. 8	476. 0	9. 0	480. 0	9. 1	400. 0	7. 6
Steel drums and pails	. 115	100. 0	11. 5	290. 0	33. 4	486. 0	55. 9	480. 0	55. 2	100. 0	11. 5
Metal strapping	. 056	100. 0	5. 6	370. 0	20. 7	486. 0	27. 2	480. 0	26. 9	100. 0	5. 6
Gas cylinders	. 008	100. 0	. 8	450. 0	3. 6	496. 0	4. 0	480. 0	3. 8	400. 0	3. 2
Metal caps	. 018	100. 0	1. 8	130. 0	2. 3	476. 0	8. 6	460. 0	8. 3	500. 0	9. 0
Metal crowns	. 029	100. 0	2. 9	130. 0	3. 8	476. 0	....	460. 0	13. 3	500. 0	14. 5
Total	1. 000		99. 9		165. 1		463. 9		463. 6		240. 5
Index Number			100. 0		170. 0		460. 0		460. 0		240. 0

[a] On the basis of tonnage share.

[b] Values calculated from Table 33 using the weighted average of factors used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

TABLE 109.—*Disposability resistance calculation: Metals, 1976*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
Steel cans	0. 679	100. 0	67. 9	130. 0	88. 3	476. 0	323. 2	460. 0	312. 3	250. 0	169. 8
Aluminum cans and ends	. 083	100. 0	8. 3	145. 0	12. 0	486. 0	40. 3	460. 0	38. 2	250. 0	20. 8
Collapsible tubes	. 001	100. 0	. 1	145. 0	. 1	476. 0	. 5	460. 0	. 5	500. 0	. 5
Rigid aluminum foil containers	. 009	100. 0	. 9	145. 0	1. 3	486. 0	4. 4	480. 0	4. 3	250. 0	2. 3
Aluminum foil converted	. 028	100. 0	2. 8	145. 0	4. 1	476. 0	13. 3	480. 0	13. 4	400. 0	11. 2
Steel drums and pails	. 093	100. 0	9. 3	290. 0	27. 0	486. 0	45. 2	480. 0	44. 6	100. 0	9. 3
Metal strapping	. 059	100. 0	5. 9	370. 0	21. 8	486. 0	28. 7	480. 0	28. 3	100. 0	5. 9
Gas cylinders	. 007	100. 0	. 7	450. 0	3. 2	496. 0	3. 5	480. 0	3. 4	400. 0	2. 8
Metal caps	. 019	100. 0	1. 9	130. 0	2. 5	476. 0	9. 0	460. 0	8. 7	500. 0	9. 5
Metal crowns	. 022	100. 0	2. 2	130. 0	2. 9	476. 0	10. 5	460. 0	10. 1	500. 0	11. 0
Total	1. 000		100. 0		163. 2		478. 6		463. 8		243. 1
Index number			100. 0		160. 0		480. 0		460. 0		240. 0

[a] On the basis of tonnage share.

[b] Values calculated from Table 33 using the weighted average of factors used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

TABLE 110.—*Disposability Ratings: Glass*

Products	Sanitary Landfill			Incineration					Composting		Salvage	
	Density 0.05	Compactibility 0.80	Degradability 0.15	Burning rate 0.75	Inert solids 0.15	Btu value 0.04	Sulfur content 0.01	Potential damage to equip. 0.05	Degradability 0.80	Suitability 0.20	Separability 0.25	Market for the commodity 0.75
Food containers	100	100	500	500	500	500	100	300	400	200	400	200
Returnable bottles	100	100	500	500	500	500	100	300	400	200	300	100
Non-returnable bottles	100	100	500	500	500	500	100	300	400	200	400	200
Drug and cosmetic containers	100	100	500	500	500	500	100	300	400	200	400	200
Household and industrial containers	100	100	500	500	500	500	100	300	400	200	400	200

Source: Midwest Research Institute.

TABLE 111.—*Disposability resistance calculation: Glass, 1966*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
Food containers	0.367	100.0	36.7	160.0	58.7	486.0	178.4	360.0	132.1	250.0	91.8
Returnable bottles	.085	100.0	8.5	160.0	13.6	486.0	41.3	360.0	30.6	150.0	12.8
Non-returnable bottles	.325	100.0	32.5	160.0	52.0	486.0	158.0	360.0	117.0	250.0	81.3
Drug and cosmetic containers	.196	100.0	19.6	160.0	31.4	486.0	95.3	360.0	70.6	250.0	49.0
Household and industrial containers	.027	100.0	2.7	160.0	4.5	486.0	13.6	360.0	10.1	250.0	7.0
Total	1.000		100.0		160.2		486.6		360.4		241.9
Index number			100.0		160.0		490.0		360.0		240.0

[a] On the basis of tonnage share.

[b] Values calculated from Table 36 using the weighted average of factors used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

TABLE 112.—*Disposability resistance calculation: Glass, 1976*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
Food containers	0.279	100.0	27.9	160.0	44.6	486.0	135.6	360.0	100.4	250.0	69.8
Returnable bottles	.036	100.0	3.6	160.0	5.8	486.0	17.5	360.0	13.0	150.0	5.4
Non-returnable bottles	.550	100.0	55.0	160.0	88.0	486.0	267.3	360.0	198.0	250.0	137.5
Drugs and cosmetic containers	.126	100.0	12.6	160.0	20.2	486.0	61.2	360.0	45.4	250.0	31.5
Household and industrial containers	.009	100.0	.9	160.0	1.4	486.0	4.4	360.0	3.2	250.0	2.3
Total	1.000		100.0		160.0		486.0		360.0		246.5
Index number			100.0		160.0		490.0		360.0		250.0

[a] On the basis of tonnage share.

[b] Values calculated from Table 36 using the weighted average of factors used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

TABLE 113.—*Disposability ratings: Wood*

Product	Sanitary Landfill			Incineration					Composting		Salvage	
	Density 0.05	Compactibility 0.80	Degradability 0.15	Burning rate 0.75	Inert solids 0.15	Btu value 0.04	Sulfur content 0.01	Potential damage to equip. 0.05	Degradability 0.80	Suitability 0.20	Separability 0.25	Market for the commodity 0.75
Nailed boxes	400	300	100	200	200	400	300	100	200	100	300	500
Wirebound boxes	400	300	100	200	200	400	300	100	200	100	300	500
Tight cooperage	400	300	100	300	200	400	300	100	200	300	300	300
Slack cooperage	400	300	100	300	200	400	300	100	200	300	300	500
Veneer packages	400	100	100	200	200	400	300	100	200	100	300	500

Source: Midwest Research Institute.

TABLE 114.—*Disposability resistance calculation: Wood, 1966*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
Nailed boxes	0.808	100.0	80.8	275.0	222.2	204.0	164.8	180.0	145.4	450.0	363.6
Wirebound boxes	.155	100.0	15.5	275.0	42.6	204.0	31.6	180.0	27.9	450.0	69.8
Tight cooperage	.007	100.0	.7	275.0	1.9	549.0	3.8	220.0	1.5	300.0	2.1
Slack cooperage	.022	100.0	2.2	275.0	6.1	549.0	12.1	220.0	4.8	450.0	9.9
Veneer packages	.008	100.0	.8	115.0	.9	204.0	1.6	180.0	1.4	450.0	3.6
Total	1.000	....	100.0	....	273.7	....	213.9	....	181.0	....	449.0
Index number				....	270.0	....	210.0	....	180.0	....	450.0

[a] On the basis of tonnage share.

[b] Values calculated from Table 39 using the weighted average of factors used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

TABLE 115.—*Disposability resistance calculation: Wood, 1976*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
Nailed boxes	0.828	100.0	82.8	275.0	227.7	204.0	168.9	180.0	149.0	450.0	372.6
Wirebound boxes	.142	100.0	14.2	275.0	39.1	204.0	29.0	180.0	25.6	450.0	63.9
Tight cooperage	.003	100.0	.3	275.0	.8	549.0	1.6	220.0	.7	300.0	.9
Slack cooperage	.023	100.0	2.3	275.0	6.3	549.0	12.6	220.0	5.1	450.0	10.4
Veneer packages	.004	100.0	.4	115.0	.5	204.0	.8	180.0	.7	450.0	1.8
Total	1.000	....	100.0	....	274.4	....	212.9	....	181.0	....	449.6
Index number			100.0	....	270.0	....	210.0	....	180.0	....	450.0

[a] On the basis of tonnage share.

[b] Values calculated from Table 39 using the weighted average of factors used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

4 OF 4

PB
204405

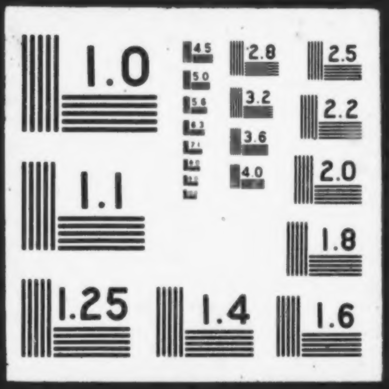

1.0
4.5
5.0
5.6
6.3
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

TABLE 116.—*Disposability ratings: Plastics*

Products	Sanitary Landfill			Incineration					Composting		Salvage	
	Density 0.05	Compactibility 0.80	Degradability 0.15	Burning rate 0.75	Inert solids 0.15	Btu value 0.04	Sulfur content 0.01	Potential damage to equip. 0.05	Degradability 0.80	Suitability 0.20	Separability 0.25	Market for the commodity 0.75
Plastic films	200	200	500	300	200	100	200	100	500	400	400	300
Bottles and tubes	200	300	500	400	200	100	200	300	500	400	400	300
Other plastic containers	200	300	500	400	200	100	200	300	500	400	400	300
Plastic closures	200	200	500	400	200	100	200	200	500	500	500	500

Source: Midwest Research Institute.

TABLE 117.—*Disposability resistance calculation: Plastics, 1966*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
Plastic films	0.599	100.0	59.9	245.0	146.8	266.0	159.3	480.0	287.5	325.0	194.7
Bottles and tubes	.217	100.0	21.7	325.0	70.5	351.0	76.2	480.0	104.2	325.0	70.5
Other plastic containers	.145	100.0	14.5	325.0	47.1	351.0	50.9	480.0	69.6	325.0	47.1
Plastic closures	.039	100.0	3.9	245.0	9.6	346.0	13.5	500.0	19.5	500.0	19.5
Total	1.000		100.0		274.6		299.9		480.8		331.8
Index number			100.0		270.0		300.0		480.0		330.0

[a] On the basis of tonnage share.

[b] Values calculated from Table 42 using the weighted average of factors used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

TABLE 118.—*Disposability resistance calculation: Plastics, 1976*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
Plastic films	0.465	100.0	46.5	245.0	113.9	266.0	123.7	480.0	223.2	325.0	151.1
Bottles and tubes	.224	100.0	22.4	325.0	72.8	351.0	78.6	480.0	107.5	325.0	72.8
Other plastic containers	.278	100.0	27.8	325.0	90.4	351.0	97.6	480.0	133.4	325.0	90.4
Plastic closures	.033	100.0	3.3	245.0	8.1	346.0	11.4	500.0	16.5	500.0	16.5
Total	1.000		100.0		285.2		311.3		480.6		330.8
Index number			100.0		290.0		310.0		480.0		330.0

[a] On the basis of tonnage share.

[b] Values calculated from Table 42 using the weighted average of factors used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

TABLE 119.— *Disposability ratings: Textiles*

Products	Sanitary landfill			Incineration					Composting		Salvage	
	Density 0.05	Compacti-bility 0.80	Degrada-bility 0.15	Burning rate 0.75	Inert solids 0.15	Btu value 0.04	Sulfur content 0.01	Potential damage to equip. 0.05	Degrada-bility 0.80	Suita-bility 0.20	Separa-bility 0.25	Market for the commodty 0.75
Textile bags........................	500	100	100	200	100	400	400	100	200	100	400	200

Source: Midwest Research Institute.

Table 120.—*Disposability resistance calculation: Textiles, 1966 and 1976*

Product	Share of total [a]	Open dump		Landfill		Incineration		Composting		Salvage, reuse, and conversion	
		Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]	Value [b]	Index [c]
1966—textile bags	1.0	100.0	100.0	120.0	120.0	190.0	190.0	180.0	180.0	250.0	250.0
1976—textile bags	1.0	100.0	100.0	120.0	120.0	190.0	190.0	180.0	180.0	250.0	250.0

[a] On the basis of tonnage share.

[b] Values calculated from Table 45 using the weighted average of factors used for each disposal process. Open dumping carries the value of 100 throughout.

[c] Index is derived by multiplying share of total market by value number.

Source: Midwest Research Institute.

APPENDIX II

Bibliography

Preceding page blank

Adam says plastics important ally for paper. *Pulp & Paper*, 41: 5–6, May 22, 1967.

Advertisers fail to note worth of packaging, management association told. *Advertising Age*, 37(17): 18, May 1966.

Aerosol production continues upward climb. *Aerosol Age*, 10(6): 24–26, June 1965.

Aerosols are up—in output but also in cost. *Modern Packaging*, 41(3):185, Dec. 1967.

Aerosols: new ways to grow. *Modern Packaging*, 40(12): 117–121, Aug. 1967.

Aerosols set new records. *Modern Packaging*, 40(7) :202–203, Mar. 1967.

ALARIE, A. Can garbage become a "national asset"? *Compost Science*, 8(1): 3–7, Spring-Summer 1967.

ALEXANDER HAMILTON INSTITUTE, INC. Spring and billions of waiting cans. *Business Conditions Weekly*, 1963.

ALEXANDER, T. Where will we put all that garbage? *Fortune*, 148–151, Oct. 1967.

ALTHOUSE, G. F. Continuous-flow refuse collection. *American City*, 81(12):90–91, Dec. 1968.

THE ALUMINUM ASSOCIATION. *Aluminum Statistical Review*, 1966.

Aluminum cans recoverable. *Science News*, 91(18): 428, May 1967.

Aluminum growth cited by official. *Steel*, 156(13): 7, Mar. 1965.

Aluminum: new dent in the 'tin' can? *Chemical Week*, 95(24): 31, Dec. 1964.

AMERICAN PAPER AND PULP ASSOCIATION. *Statistics of paper*. 8th ed., 1964. 106 p.

AMERICAN PAPER INSTITUTE, INC. *Paperboard industry statistics, 1966*. New York, 1967. 29 p.

AMERICAN PAPER INSTITUTE, INC. *The statistics of paper: 1967 supplement.*

An interesting and—newly emerging—trend is to adapt film-structuring techniques to other containers. *Modern Packaging*, 40(8): 103, Apr. 1967.

Another PVC first: shampoo. *Modern Packaging*, 38(12): 103, Aug. 1965.

ANREDER, S. S. Cardboard lovers. *Barron's*, 46:3–4, Feb. 28, 1966.

Applying technology to unmet needs; a report on the solid waste problem. Appendix v. 5. *In* National Commission on Technology, Automation, and Economic Progress. *Technology and the American economy; report of the Commission.* Washington, U.S. Government Printing Office, 1966. p. V161–V174.

Approved: a returnable plastics milk bottle. *Modern Packaging*, 39(5): 94–96, Jan. 1966.

ARMSTRONG, W. L., *tr.*, and J. S. WILEY, *ed.* International Research Group on Refuse Disposal (IRGR). Information Bulletins No. 13 and 14. Washington, U.S. Government Printing Office. 84 p.

ARTHUR, D. LITTLE, INC. *The role of packaging in the U.S. economy; a report to the American Foundation for Management Research, Inc.*, 1966.

Asbestos: awaiting "trial." *Chemical Week*, 99(11): 32, Sept. 1966.

THE ASSOCIATED COOPERAGE INDUSTRIES OF AMERICA, INC. *The wooden barrel manual*, 22(1), Sept. 1951.

ATTIG, G. K., and J. CLAY. Put "teeth" into compaction. *American City*, 81(3): 88–90, Mar. 1966.

Background for packaging. *Modern Packaging*, 36(12): 41, Aug. 1963.

Background for packaging. *Modern Packaging*, 39(5): 47, Jan. 1966.

Background for packaging. *Modern Packaging*, 39(11): 43, June 1966.

Background for packaging. *Modern Packaging*, 40(8): 39, Apr. 1967.

Background for packaging. *Modern Packaging*, 40(9): 41, May 1967.

Background for packaging. *Modern Packaging*, 40(12): 41, Aug. 1967.

Background for packaging. *Modern Packaging*, 41(3): 44, Nov. 1967.

Back to bags. *Modern Packaging*, 39(9): 113–118, May 1966.

BALDWIN, N. T. Industry optimism warranted. *Paperboard Packaging*, 50 (8): 126–127, Aug. 1965.

Preceding page blank

Baldwin, N. T. And still no satisfactory substitute. *Paperboard Packaging*, 52(8): 103–105, Aug. 1967.

Barnes, S. The great garbage explosion. *Machine Design*, 38(3): 100–109, Feb. 1966.

Barnes, S. The disposal gap. *Machine Design*, 38(7): 144–149, Mar. 1966.

Battle of the bag. *Forbes*, 92: 50, Nov. 1, 1963.

Battle over cans stiffens. *Chemical Week*, 95(16): 85–86, Oct. 1964.

Beizer, J. Aluminum welcomes packaging fight. *Iron Age*, 196(15): 29, Oct. 1965.

Bennett, K. W. Packaging wraps up sales gains. *Iron Age*, 195(15): 26–27, Apr. 1965.

Berkin, H. H. What the baking industry needs from packaging material suppliers. *Paper Trade Journal*, 40–41, Nov. 1964

Bettendorf, H. J. Packaging in educated, mobile societies. *Paperboard Packaging*, Aug. 1962.

Bettendorf, H. J. Yardsticks of box growth—for Canada or other countries. *Paperboard Packaging*, 1–4, Oct. 1962.

Bettendorf, H. J. Paperboard mill section. *Paperbord Packaging*, 57–67, Aug. 1967.

Better barrier pouch for milk. *Modern Packaging*, 109, Dec. 1967.

Better diet for oxygen steelmakers. *Business Week*, 178, June 1966.

Biaxial orientation ups soluble-film strength. *Chemical Engineering*, 108–110, Nov. 1964.

Big package deal in Chicago. *Chemical Week*, 117–119, Apr. 22, 1967.

Big things are happening in PVC films—in packaging. *Modern Plastics*, 94–97, Aug. 1961.

Billings, C. H. Operation "big squeeze" takes on refuse disposal. *Public Works*, 87–88, Jan. 1966.

Bioriented rigid PVC sheeting. *Modern Packaging*, 136, Aug. 1965.

Bishop, W. D., R. C. **Carter**, and H. F. **Ludwig**. Gas movement in land-filled rubbish. *Public Works*, 64–68, Nov. 1965.

Black, R. J., and P. L. **Davis**. *Refuse collection and disposal: an annotated bibliography, 1960–1961*. Public Health Service Publication No. 91. Washington, U.S. Government Printing Office, 1963. Suppl. E.

Blumenthal, L. A. Scramble in the marketplace. *Dun's Review and Modern Industry*, 86–87, Dec. 1965.

Board coating. *Paperboard Packaging*, 23–25, Mar. 1967.

Board output up 4 percent in latest week. *Fibre Market News*, 1, June 16, 1967.

Bogue, M. D. Municipal incineration. Cincinnati, U.S. Department of Health, Education, and Welfare, 1968. 27 p.

Boom in plastics shipping bags. *Modern Packaging*, 34–35, Feb. 1964.

Booth, E. J. Buried 25 years and still legible. *American City*, 26, July 1965.

Braun, P. A regional refuse-disposal solution. *American City*, 96–97, Dec. 1967.

Braun, R. Reutilization of solid waste by composting. *Secondary Raw Materials*, 41–42, Nov. 1967.

Brighter future seen for flexible packaging. *Modern Packaging*, 39(10): 202–203, July 1966.

Broussard, J. P. Properties of ionomers: films. *Modern Packaging*, 40(9): 173–175, June 1967.

Brown, V. How much does composting cost per ton?: away from the "slop and ashes" of yesteryear. *Compost Science*, 8(1): 16–17, Spring-Summer 1967.

Broyles, H. C. "Papercans" versus metal cans. *Current Municipal Problems*, 5(4): 75–81, May 1964.

Bureau of Labor Statistics. The Glass Container Industry (SIC 3221). *Technological trends in major American industries*. U.S. Department of Labor, Bureau of Labor Statistics, 1966. p. 51–52.

Burkinshaw, L. D. Polycarbonates for packaging. *Modern Packaging*, 37(9): 147–150, June 1964.

Burvant, R. Factors affecting packaging in future. *Food Engineering*, 39(8): 46–47, Mar. 1966.

Busch, T. W. Paper coating additives. *Tappi*, 49(6): 34–38, June 1966. CSMA notes trend to large can sizes. *Printers' Ink*, 290:31, Mar. 1965.

CAMERON, F. B. Packaging in plastics: plastics in packaging. *Plastics World, 23*(3): 16–18, Mar. 1965.

Can engineering cope with the debris of affluence? *Product Engineering,* 38(21): 37–44, Oct. 1967.

CAN MANUFACTURERS INSTITUTE, INC. *Metal cans shipments, 1966.*

CAN MANUFACTURERS INSTITUTE, INC. *Steel, tin, aluminum consumed in metal cans,* 1963.

Can plastics. *Plastics World,* 18(6): 30, June 1967.

Canmakers are putting new barrier linings inside their packages (both composite and metal). *Modern Packaging,* 40(8): 122–332, Apr. 1967.

Cans: a passion for obsolence. *Modern Packaging,* 40(6): 118–123, Feb. 1967.

Cans: when will packagers reap the big economies of new materials? *Modern Packaging,* 41(1): 299–301, Sept. 1967.

CAPP, J. P. Fly ash utilization. *Combustion,* 37(8): 36–40, Feb. 1966.

Captive blow molding—milk shows the way. *Modern Packaging,* 40(6): 102–108, Feb. 1967.

Car junkyards try sophistication. *Business Week,* 108–112, Feb. 26, 1966.

A cargo of grief for U.S. steelmakers. *Fortune,* 141, Oct. 1967.

Cartons look for half '66 gain in '67. *Paper, Film, and Foil Converter,* 46, Feb. 1967.

CARTY, T. M. What's the latest on plastic milk bottles? *Modern Plastics,* 88–91, Feb. 1966.

CASTAGNE, M. R. Paper bags show steady growth—producers optimistic for future. *Paper Trade Journal,* 43–44, May 24, 1965.

CASTAGNE, M. R. What's new in coating '64. *Pulp & Paper,* 37–40, Apr. 1964.

Challenge & response. *Forbes,* 56–57, Feb. 1967.

Challenge of a complex industry met by aluminum adaptability. *Quick Frozen Foods,* 62, July 1962.

The changing can picture. *Financial World,* 10–11, May 1966.

Chasing the waste. *The Economist,* 728, Feb. 1966.

Chemical giants eye another major market: plastic gallon and half-gallon milk packs. *Printers' Ink,* 12, Dec. 1964.

Chemical industry & packaging: not yet fully aware of impact in this $26 billion business. *Oil Paint and Drug Reporter,* 7, Mar. 1966.

Chemical profile polyethylene—H D. *Oil, Paint and Drug Reporter,* 3, Oct. 1967.

Chemical profile polyethylene—L D. *Chemical Marketing,* 9, Oct. 1967.

City-county development of a sanitary landfill. *Public Management,* 63, Apr. 1965.

CLARK, P. S. Can aerosols spray their troubles away? *Industrial Design,* 50–56, May 1967.

CLARK, P. S. The coming (any minute) revolution for plastics. *Industrial Design,* 64–69, Oct. 1967.

CLARK, P. S. Some impressive developments in technology and design. *Industrial Design,* 78–83, June 1967.

CLARY, B. Wax: its past, present & future. *Paperboard Packaging,* 31–35, July 1967.

Closures show ingenuity. *Food Engineering,* 102–103, Mar. 1965.

Coating competition stiffens. *Chemical Week,* 103–104, Nov. 1964.

Coatings and adhesives wrap up sophisticated needs in packaging. *Oil, Paint and Drug Reporter,* 44, Dec. 1966.

Coatings for paper. *Chemical and Engineering News,* 86–93, Sept. 1963.

Cold-workable new plastic may punch out big market. *Chemical Engineering,* 108, May 1967.

COMMITTEE ON SOLID WASTES, AMERICAN PUBLIC WORKS ASSOCIATION. *Municipal refuse disposal.* 2d ed. Chicago, Public Administration Service, 1966. 526 p.

COMMITTEE ON SOLID WASTES, AMERICAN PUBLIC WORKS ASSOCIATION. *Refuse collection practice,* 3d ed. Chicago, Public Administration Service, 1966. 525 p.

Companies fail to use packages as medium, packaging conference told. *Advertising Age,* 36(14): 43–45, Apr. 1965.

Composites to improve bag-in-box. *Package Engineering,* 12(4): 14, Apr. 1967.

The composting game: Mobile loses—Houston takes chance. *Refuse Removal Journal,* 9(8): 36–38, Aug. 1966.

Consumer and Marketing Service, Dairy Division. *Packaged fluid milk sales in federal milk order markets—by size and type of containers and distribution method—during November 1965.* Publication C & MS–11 (Nov. 1965). U.S. Department of Agriculture Consumer and Marketing Service, Dairy Division, Mar. 1967. 46 p.

Consumer markets—big, different in 1987. *Chemical & Engineering News*, 45(15): 28–31, Apr. 1967.

Consumer attitudes to aerosols reported in Union Carbide study. *Aerosol Age*, 11(8): 57–58, Aug. 1966.

Container seeks a bigger package. *Business Week*, 185–188, Oct. 1967.

Containers & closures. *Metalworking Weekly*, 17, Mar. 1965.

Converting perspectives 1967. *Paper, Film and Foil Converter*, 41(2): 44–46, Feb. 1967.

Cook-in aluminum cans. *Modern Packaging*, 37(4): 97, Dec. 1963.

Cooke, L. M. Shrinkable polyethylene films. *Plastics World*, 24(4): 28–29, Apr. 1966.

Copolymer plastic refuse-can liners . . . trim 20 percent off refuse-collection time. *American City*, 81(6): 100–101, June 1966.

Corporations: scrappy market. *Time*, 89(18): 98–100, May 1967.

Corrugated & solid fiber section. *Paperboard Packaging*, 52(8): 74–82, Aug. 1967.

Corrugated box shipments hit all-time high. *Pulp & Paper*, 37: 13, Oct. 1963.

Corrugated container for ships' stores. *Transportation & Distribution Management*, 43–45, July 1967.

Corrugated: peaking out or pushing up? *Modern Packaging*, 40(11): 102–107, July 1967.

Cuscaden, R. At Downing Box: scrap handling comes of age. *Paperboard Packaging*, 52(5): 17–20, May 1967.

Cuscaden, R. Shrinkage and the grocery products industry. *Paperboard Packaging*, 27–28, Jan. 1967.

Davis, P. L., and R. J. Black. Effects of garbage grinding on sewage systems and environmental sanitation. *APWA Reporter*, 29(12): 16–18, Dec. 1962.

Dawson, S. Glass, metal, plastics and paper in spirited rivalry. *Kansas City Star*, Sept. 21, 1964.

DeLong, R. F., and J. F. Helms. New film combinations. *Modern Packaging*, 151–157, Nov. 1965.

Designing closures for dual purpose. *Modern Plastics*, 116–119, 192, 194, Sept. 1964.

Disposal system makes cash from trash. *Engineering News-Record*, 32, Mar. 1964.

Dobrow charts '66 paper prospects, predicts production, profit records. *Pulp & Paper*, 7–8, Feb. 1966.

Dooley, D. D. Hot melt adhesives: why they are so popular. *Material Handling Engineering*, 66–69, Feb. 1966.

Drop shows Witt can can take it. *Advertising Age*, 44, Dec. 1964.

Drugs and food preservatives: ideas of EEC opening markets and simplifying sales efforts. *Oil, Paint and Drug Reporter*, 3, Apr. 1965.

Duncan, S. Future of paper and board in frozen food packaging. *Paper Trade Journal*, 48–51, May 1965.

EVA resin coatings. *Modern Packaging*, Apr. 1966.

Edible, transparent films for frozen foods. *Quick Frozen Foods*, 35–37, May 1964.

Electrostatic gravure goes to market. *Paper, Film and Foil Converter*, 59, Feb. 1967.

Engineers ponder need for novel concepts. *Modern Packaging*, 120–123, Sept. 1967.

Equipment and materials. *Modern Packaging*, 52, Dec. 1966.

Easrove, D. Thermoplastic polyurethanes. *Modern Packaging*, 130–135, Jan. 1966.

Evans, J. C. W. How important is converting to paper and board manufacturers? *Paper Trade Journal*, 30–31, Aug. 1967.

Evans, H., Jr. A new idea in landfill operation. *American City*, 114-115, Mar. 1967.

Explosive growth due for PVC bottles. *Chemical and Engineering News*, 25–26, Feb. 1966.

Faltermayer, E. K. How to wage war on ugliness. *Fortune*, 130–134, May 1966.

Federal attack proposed for environmental health woes. *Chemical Engineering*, 74(14): 50, July 1967.

Fedor, W. S. Consumer spending foretells plastics demand. *Chemical and Engineering News*, 45: 84–94, Nov. 20, 1967.

Fehn, C. F., J. O. Hall, M. Rosenthal, J. R. Cain, J. H. Rigsby, and H. Farmer. Bulk storage and mechanized collection of combined refuse. *Public Works*, 95(9): 130–131, Sept. 1964.

Feldmuhle, M. J. Coated printings: what is needed in the future. *Pulp & Paper*, 40(38): 42–48, Sept. 1966.

Ferguson, Brooks & Kelly, and W. L. Armstrong, *trs.*, and J. S. Wiley, *ed.* International Research Group on Refuse Disposal (IRGR). Information Bulletins No. 15 and 16. Washington, U.S. Government Printing Office, 1964. 58 p.

Ferguson, Brooks & Kelly, *trs.*, and J. S. Wiley, *ed.* International Research Group on Refuse Disposal (IRGRD). Information Bulletins No. 19 and 20. Washington, U.S. Government Printing Office, 1965. 68 p.

Fife, J. A. European refuse disposal. *American City*, 81(9): 125–128, Sept. 1966.

Film bundling saves 50 percent. *Modern Packaging*, 41(2): 152–153, Oct. 1967.

Film package without film. *Modern Plastics*, 43(10): 80–81, June 1966.

Fibre Box Association. *Fibre Box Industry Statistics 1966.*

Fleming, R. R. Solid waste disposal. *American City*, 81(1): 101–104, Jan. 1966.

Fleming, R. R. Solid waste disposal: incineration and composting. *American City*, 81(2): 94–96, Feb. 1966.

Flexible packaging: the common denominators. *Modern Packaging*, 41(3): 136–141, Nov. 1967.

Flexible packaging: confused and complicated. *Modern Packaging*, 41(2): 122–127, Oct. 1967.

Flexible packaging: the overlooked components. *Modern Packaging*, 41(4): 112–117, Dec. 1967.

Flexible packaging: something for everything. *Modern Packaging*, 40(8): 137–140, 281–336, Apr. 1967.

Flexography: how big in corrugated? *Modern Packaging*, 41(1): 142–145, Sept. 1967.

Fly ash utilization makes slow progress. *Power*, 111(5): 116–120, May 1967.

Folding Paper Box Association of America. *The Folding Paper Box Industry Statistics for 1966*, 1966.

For a more beautiful U.S., the President asks this—. *U.S. News and World Report*, 59(8): 71, Feb. 1965.

For better breathing: a landfill. *American City*, 80(10): 62, Oct. 1965.

Forecast for PVC bottles: clearing. *Modern Plastics*, 44(1): 105–109, Dec. 1966.

Foreseeable future of polycoatings in packaging. *Paper Trade Journal*, 147(17): 147–149, Apr. 1963.

Fox, G. G. Paper bag disposal system finds ready acceptance. *Public Works*, 71–72, Nov. 1964.

Friends, foes, and forecasts for the old tin can. *Marketing Magazine*, 61–63, Jan. 1967.

Fulmer, M. E., and R. F. Testin. The role of plastics in solid waste. A study done for the Society of the Plastics Industry, Inc., 1967.

Fundamentals of sanitary landfill operation. *Public Works*, 88–89, Dec. 1964.

Furlow, H. G., and H. A. Zollinger. Reclamation of refuse. *Current Municipal. Problems*, 18–29, Jan. 1966.

Future boom seen for gas incinerators. *American Gas Journal*, 49–52, Oct. 1965.

Garbage for health and power. *Business Week*, 82, July 1, 1967.

Garbage heaps are mountainous problem for many major cities. *The Kansas City Star*, Apr. 17, 1967. p. 16.

Garbage in, merchandise out. *Scientific American*, 58, Jan. 1967.

Gaulke, R. G. Dramatic foil container advances combine sense with imagination. *Quick Frozen Foods*, 60, July 1962.

Gilbertson, W. E., and R. J. Black. A national solid waste program is created. *Compost Science*, 6(3): 4–7, Autumn-Winter 1966.

Glace, M. M., Jr. A new type of municipal incinerator. *American City*, 89–93, Nov. 1959.

Glass. *Chemical and Engineering News*, 80–85, Nov. 1964.

Glass Container Manufacturers Institute, Inc. *Glass Containers, 1966*, 1966.

Glass containers: belabored by uncertainty. *Modern Packaging*, 177–180, July 1967.

Glass: fighting back with new strength. *Modern Packaging*, 112–116, Jan. 1967.

Glass makers institute adds impetus to no-returns with $5,200,000 drive. *Advertising Age*, 10, July 4, 1966.

GLENN, D. A. Folding carton trend analysis. *Paperboard Packaging*, 126–127, Aug. 1963.

GOOD, I. L. Outsize trash collection proves popular. *American City*, 35, Jan. 1967.

Goodrich gets license for rigid, clear PVC bottle. *Chemical and Engineering News*, 22 Nov. 1967.

GORDON, M. Cities' rubbish woes grow as volume rises, dumping sites fill up. *The Wall Street Journal*, Oct. 18, 1961.

Government guideline. *Modern Packaging*, 41(1): 253–254, Sept. 1967.

GRUENDLER, W. P. How much does composting cost per ton?: salvage income at Mobile, Alabama, plant. *Compost Science*, 8(1): 18, Spring-Summer, 1967.

GRUENWALD, A., and J. A. REYNOLDS. Less than $3,000 per ton. *American City*, 80(10): 100–101, Oct. 1965.

GUSS, L. M. *Packaging Is Marketing*. American Management Association, 1967.

HPI Newsletter. *Hydrocarbon Processing*, Jan. 1966. p. 13.

HANKILA, M. Fill first, then compact. *American City*, 81(5): 173–174, May 1966.

HANKS, J. J., and H. D. KUBE. Industry action to combat pollution. *Harvard Business Review*, 44: 49–62, Sept.-Oct. 1966.

HAUCK, J. E. Flame-retardant plastics quash smoke, noxious gases. *Materials Engineering*, 66(3): 80–83, Sept. 1967.

Heat recovery makes garbage less a burden. *Chemical Engineering*, 74(16): 72–73, Aug. 1967.

Heat sealing of polyolefins. *Modern Packaging*, 38(8): 139–144, Apr. 1965.

HERNANDEZ, G. Deep-hole method extends landfill use. *American City*, 82(3): 17, Mar. 1967.

HERSHSON, M. Reconditioned steel drums, economies and advantages. A report presented before the Petroleum Packaging Committee in Philadelphia, Pennsylvania, June 1964. A reprint from the National Barrel & Drum Association.

Highlights from the packaging show. *Modern Packaging*, 40(10): 113–115, June 1967.

HIRSCH, W. Z. Cost functions of an urban government service: refuse collection. *Review of Economics and Statistics*, 87–92, Feb. 1965.

HOFFMAN, D. A. "Burns" refuse without a flame. *American City*, 82(2): 102–104, Feb. 1967.

HOLHEUZER, O. Steel wheel dozer improves landfill compaction. *Public Works*, 98(4): 119, Apr. 1967.

The hot melts. *Modern Packaging*, 38(2): 113–118, Oct. 1964.

Household products leading nonfood aerosols. *Department Store Economist*, 29(4): 91–92, Apr. 1966.

How big is plastics in packaging? *Modern Plastics*, 44(9): 98, May 1967.

How to dispose of disposables? *Chemical Week*, 101(11): 32–33, Sept. 1967.

HUFFMAN, G. L. Town meeting on milk packaging paper. *In* Milk Industry Foundation—Convention Proceedings, Sales and Advertising Section, 1965. p. 40–44.

HUGHES, W. E. A consolidation after unprecedented gains. *Paperboard Packaging*, 101–102, Aug. 1967.

Illinois agency adopts refuse disposal policy. *National Civic Review*, 383, July 1963.

In Chicago, it was "tell us what you want". *Modern Packaging*, 148–154, June 1967.

In London, it was innovation. *Modern Packaging*, 112–116, July 1967.

In-plant plastic bottle service. *Paperboard Packaging*, 123, Aug. 1967.

In the U.S.: Government report predicts many 1967 gains. *Pulp & Paper*, 5 Mar. 1967.

Industrial packaging battles nonpackaging. *Modern Packaging*, 136–141, Oct. 1967.

Industry arms for war on waste. *Chemical Week*, 78–80, Jan. 1960.

Industry statistics. *Paperboard Packaging*, 149, Aug. 1967.

Industry trends: paperboard output picture for 1966. *Paper Trade Journal*, 7, Jan. 1967.

Industry trends: the industry in 1966. *Paper Trade Journal*, 7, Feb. 1967.

Industry trends: Slatin—supply/demand picture: total industry. *Paper Trade Journal*, 7–8, Jan. 1967.

Industry-wide market for shipping bags seen with new use by Diamond Crystal. *Printers' Ink*, *12*, July 1964.

INGLE, G. W. PVC and the F&DA—a status report. *Modern Packaging*, 137–139, Mar. 1966.

Integrated bulk packaging system via polyethylene shrink film. *Modern Plastics*, 45(3): 116, Nov. 1967.

Ionomer: a new thermoplastic. *Modern Plastics*, 42(1): 98–99, 209, Sept. 1964.

It's like corrugated paperboard, except . . . *Modern Plastics*, 45(1): 97, Oct. 1967.

JACKSON, P. Refuse container-train collection system results in savings. *Public Works*, 98(2): 74–75, Feb. 1967.

JONES, R. F. Improved polypropylene for bottles. *Modern Packaging*, 41(1): 180–183, Sept. 1967.

KAISER, E. R. Composition and combustion of refuse. In *Proceedings, MECAR Symposium Incineration of Solid Wastes, American Society of Mechanical Engineers*, Process Industries Division, New York, March 21, 1967. New York Metropolitan Engineers Council on Air Resources, 1967. p. 1–9.

KAPLAN, M. What's the future for fibre cans? *Paperboard Packaging*, 50(8): 132–133, Aug. 1965.

KEARNS, J. T. Licensed haulers. *American City*, 82(2): 60, Feb. 1967.

KEITH, J. A. Pawtucket's two-pronged attack. *American City*, 8(18):108–109, Aug. 1966.

KOCH, A. S. Sanitary landfill lives up to county's expectations. *Public Works*, 96(7): 70–71, July 1965.

Kneax: boon to papermaking industry? *Agricultural Research*, 15(7): 11, Jan. 1968.

LACK, A. Opinion: a housewife says. *Modern Packaging*, 41(1): 98–100, Sept. 1967.

LAMAR, S. T., and A. A. D'ADDIECO. Barrier properties of paper coated with blends of ethylene vinyl acetate copolymers and wax. *Tappi*, 48(7): 28–32, July 1965.

Laminated-plastic shipping bags make market debut. *Chemical Engineering*, 72(17): 80, Aug. 1965.

LASTELIC, J. K. U. to offer Ph.D. for garbage men. *Kansas City Star*, June 1, 1967. p. 1.

LATHROP, E. C., S. I. ARONOVSKY, S. B. KNAPP, F. W. O'NEIL, R. G. HITCHINGS, A. J. ERNST, and T. F. CLARK. Fiber shipping containers from sugar cane bagasse. *Tappi*, 40(10): 787, Oct. 1957.

LATHROP, E. C., T. F. NAFFZIGER, and E. R. STIVERS. Boxboard from wheat straw to replace wood veneer in wire-bound shipping containers. *Tappi*, 34(4): 145–152, Apr. 1951.

Lighter fluid: breakthrough for PVC. *Modern Packaging*, 40(12): 110–113, Aug. 1967.

LOEHWING, D. A. Flipping their lids. *Borron's* 47: 3–8, May 29, 1967.

LORDI, F. E., and E. D. SHUSTER. Making PE containers from sheet. *Modern Plastics*, 44(8): 123–126, Apr. 1967.

LUCIA, F. J. Disposal of bulk wastes. *Public Works*, 95(10):100–102, Oct. 1964.

Luke: packaging to double by 1975. *Printers' Ink*, 294: 67, Apr. 1967.

LYNCH, L. W. Evaluations of plastics films. *Modern Packaging*, 177–183, Oct. 1964.

MCALLISTER, J. Food store packages as consumers see them. *Sales Management*, 60–70, June 1966.

MCALLISTER, J. Food store packages as consumers see them. *Sales Management*, 40–52, July 1966.

MCCARTHY, V. D. Plastic-coated paperboard broadens market for resins. *Quick Frozen Foods*, 68–69, July 1962.

MCELWEE, W. From landfills to streets. *American City*, 24, Apr. 1966.

McKeever, F. Paper explosion in the institutions market. *Paper Trade Journal*, 72–73, Dec. 1965.

McKinney, R. E. The imminent solid-waste crisis. *American City*, 23, June 1966.

McLaughlin, D. T. Folding carton section. *Paperboard Packaging*, 83–91, Aug. 1967.

McManus, G. J. Will aluminum come to the rescue of the tinplate producers? *Iron Age*, 23–24, Nov. 1964.

Made from corn: edible, fully soluble, transparent barrier film. *Farm Chemicals Magazine*, 114–115, Nov. 1967.

Mailey, H. V. Landfill: from eyesore to asset. *Public Works*, 95–96, Nov. 1964.

Making PE containers from sheet. *Plastics Engineering*, 123–126, 201–202, Apr. 1967.

Market Newsletter. *Chemical Week*, 53, Aug. 12, 1967.

Materials: the battle rages. *Dun's Review and Modern Industry*, 88–89, Dec. 1965.

Mather, G. Continuing to grow at a healthy rate. *Paperboard Packaging*, 95–96, Aug. 1967.

Mather, G. Paper cans—most dynamic converting operation today. *Paper Trade Journal*, 55–62, May 1965.

Mauser, F. F. The future challenges marketing. *Harvard Business Review*, 168–188, Dec. 1963.

May, R. B. Scrap-steel shredding units law changes could solve cities' derelict cars problem. *The Wall Street Journal*, May 9, 1967. p. 3.

May, W. F. Advances in plastics packaging. *Plastics World*, 23, Jan. 1965.

May, W. F. Plasti—"quote". *Plastics World*, 12, Jan. 1965.

Metal of future is getting there. *Business Week*, p. 116, June 1967.

Metals fight to hold their beer. *Business Week*, 92–94, Mar. 1967.

Metals go modern. *Food Engineering*, 37(3): 96–98, Mar. 1965.

Meyer, W. Equipment and processes for paper bonding. *Adhesive Age*, 9(9): 22–26, Sept. 1966.

Michaels, A. Solid waste disposal. *Waste Management*, D-1—D-5, Dec. 1966.

Mix, S. A. Solid wastes: every day, another 800 million pounds. *Today's Health*, 44(3): 13–17, Mar. 1966.

Mock, J. A. Control glass properties with films and coatings. *Materials Engineering*, 66(3): 90–93, Sept. 1967.

Modern Packaging: Encyclopedia Issue 1965, 38 (3A), Nov. 1964.

Modern Packaging: Encyclopedia Issue 1966, 39 (4A), Dec. 1965.

Modern Packaging: Encyclopedia 1967, 40(13A), Sept. 1967.

Modern Packaging: Encyclopedia Issue 1967, 40 (4A), Dec. 1966.

Modern Plastics: Encyclopedia Issue 1966, 43(7A), Sept. 1965.

Modern Plastics: Encyclopedia Issue 1967, 44(1A), Sept. 1966.

Molded structural foams are starting to move. *Modern Plastics*, 44(8): 96–101, Apr. 1967.

Money in the garbage can. *Fortune*, 75: 226, Apr. 1967.

Moore, W. M. Tepee refuse burner has extension dome. *American City*, 80(8): 165, Aug. 1965.

More bounce where it counts. *Chemical Week*, 96(14): 56–60, Apr. 1965.

More profitable markets for plastics. *Plastics World*, 24(4): 34–35, Apr. 1966.

More refuse collected with less work. *American City*, 80(7): 26, July 1965.

National Canners Association. *The Canning Industry*, 1963.

Naturally smokeless incinerators. *Science News*, 91(17): 403, Apr. 1967.

Navy develops test for PS foam packages, makes big savings. *Modern Plastics*, 44(10): 104–106, June 1967.

Neal, H. R. Scrap has a bundle of problems. *The Iron Age*, 197(25): 73–78, June 1966.

Nelson, A. Z. Problems, potential of the paper stock industry. *Secondary Raw Materials*, 56–59, Nov. 1967.

New bounce for plastic bottles. *Modern Plastics*, 115–236, June 1966.

New fiber to feed pulpers. *Chemical Week*, 81, Nov. 1967.

New foam contender. *Chemical Week*, 43, July 1967.

New heavy duty crusher-disintegrator solves many municipal waste disposal problems. *Secondary Raw Materials*, 39–40, Nov. 1967.

New ideas in materials applications. *Materials Engineering*, 30, Nov. 1967.

New incinerator fights pollution. *The Oil and Gas Journal*, 58–59, Sept. 1967.

New incinerator to feature electrostatic precipitator. *American City*, 36, Dec. 1966.

New know-how prompts brewers to diversity. *Chemical Engineering*, 60–62, Aug. 1967.

New packaging. *Printer's Ink*, 72–73, May 1967.

New Packaging. *Printer's Ink*, 79, Oct. 1965.

New pastures for milk cartons. *Modern Packaging*, 136–139, Sept. 1967.

Newest coatings add strength and variety. *Food Engineering*, 52–53, Mar. 1965.

1964 scrap consumption best in eight years. *The Iron Age*, 270, Jan. 1965.

1964 aerosol output topped 1.3 billion units. *Chemical and Engineering News*, 34–36, May 1965.

1966 problem of choice. *Modern Packaging*, 133–142, Apr. 1966.

1966 U.S. production rose 6.4 percent to 46.5 million tons. *Pulp & Paper*, 5, Apr. 1967.

1966—Year of big change for composite cans. *Chemical & Engineering News*, 26–27, May 1966.

1967: A bigger horn of plenty for packagers. *Modern Packaging*, 122–127, Apr. 1967.

No cover material needed for converted refuse. *American City*, 18, Feb. 1966.

Nonstop sanitary landfill. *American City*, 8, May 1958.

Not paper, not textiles, but pure polytetrafluoroethylene. *Chemical Engineering*, 66–68, Aug. 1965.

Now: foods hot-packed in a pouch. *Modern Packaging*, 146–148, May 1966.

NUTTALL, E. P. Magnitude of new pulping capacity threatens market stability. *Paperboard Packaging*, 61–142, Aug. 1965.

Officials seek answer to trash problems. *Kansas City Times*, 5, June 1967.

The official totals are in. *Modern Plastics*, 44(2): 110–112, Oct. 1966.

The old trash dump is obsolete. *Engineering News-Record*, 176: 20, Apr. 1966.

Only a few do thorough package research. *Printer's Ink*, 15–17, Apr. 1967.

Outlook for polystyrene foam. *Modern Plastics*, 44(11): 75–80, July 1967.

Output up 5.5 percent in 1965, use at 495 lbs. each. *Pulp & Paper*, 40(1): 5, Jan. 1966.

Owens-Illinois says new process yields more colorful bottles. *Wall Street Journal*, Oct. 1964.

PE future is in the bag. *Oil, Paint and Drug Reporter*, TPI–04, 3, Jan. 1965.

PR for refuse collection. *Public Management*, 44(8): 187–188, Aug. 1962.

PVC's 1966 sales could pass 2 billion pounds. *Chemical and Engineering News*, 44(1): 18, Jan. 1966.

Packaging—a 4.5 billion-lb. plastics market by 1970. *Modern Plastics*, 45(5): 92–97, 191, Jan. 1968.

Packaging—a market that accommodates both the giant and the little guy is poised for phenomenal growth. *Modern Plastics*, 43(9): 202–204, May 1966.

Packaging and pollution. *Printer's Ink*, 294: 61, Apr. 1967.

Packaging economics. *Modern Packaging*, 41(3): 243–250, Nov. 1967.

Packaging economics: plastics pace closure growth. *Modern Packaging*, 40(12): 207–210, Aug. 1967.

Packaging economics: price problems in rigid-plastic containers. *Modern Packaging*, 40(10): 247–265, June 1967.

Packaging: a giant matures. *Modern Packaging*, 39(9), May 1966.

Packaging: bottles up to scratch. *Economist*, 210: 632, Feb. 1964.

Packaging. *Forbes*, 99: 39, Jan. 1967.

Packaging growth: robust and dynamic. *Modern Packaging*, 40(5): 120–126, Jan. 1967.

Packaging lags behind economy but its benefits to consumers grow: little. *Advertising Age*, 37, Apr. 1966.

Packaging 1967. *Dun's Review and Modern Industry*, 88(5): 133–154, Nov. 1966.

Packaging pacemakers. *Modern Packaging*, 40(4): 122–125, Dec. 1966.

Packaging: profit and performance. *Dun's Review and Modern Industry*, 89–144, Dec. 1964.

Packaging trends. *Food Processing & Marketing*, Apr. 1967.

Packaging wraps up the future. *Fortune*, 123–126, Feb. 1967.

The Paper Bag Institute, Inc. *Grocer's Bags and Grocer's Sacks*, 1966.

The Paper Bag Institute, Inc. *Merchandise Bags*, 1966.

Paper bags for household refuse handling—a study in depth. *Paper Trade Journal*, 39, Oct. 1963.

Paper bags used in new refuse collection plan. *Public Management*, 229, Oct. 1962.

Paper in captive converting. *Modern Packaging*, 95–97, Mar. 1967.

Paperboard in the general economy. *Paperboard Packaging*, 29–36, Aug. 1967.

Paperboard in general economy. *Paperboard Packaging*, 132, Aug. 1960.

Paperboard: recovery from its ills. *Modern Packaging*, 112–118, Mar. 1967.

Para-xylenes yield new engineering plastics. *Chemical Engineering*, 48–52, Mar. 1965.

A partial answer to the scrap-yard burning problem. *American City*, 8, May 1958.

Paul, P. F. Sources of strength in the fibre box industry. *Paperboard Packaging*, 57, Oct. 1961.

Pedo, D. J. Reorganization cuts refuse collection costs. *Public Works*, 110–111, July 1964.

Pepsi's switch to aluminum. *Sales Management*, 94–95, Mar. 1967.

Perino, D. A. Current converting/packaging trends. *Paper, Film and Foil Converter*, 64–65, Feb. 1967.

Permit greaseproofing cheap substrates. *Package Engineering*, 121, Apr. 1967.

Pilaro, J. F. Polyethylene-coated cartons. *Quick Frozen Foods*, 64–65, July 1963.

Pinkerton, W. S., Jr. How a major industry hustles, shades prices as its boom runs out. *Wall Street Journal*, June 1967.

Pinsky, J., P. J. Jannke, and H. M. Beal. Drugs in plastics containers. *Modern Packaging*, 156–162, Dec. 1965.

Plain talk for packagers. *Modern Packaging*, 89–93, July 1967.

Plastic "blisters" encase more products on retail counters. *Wall Street Journal*, May 1967.

Plastic bottle use grows. *Chemical & Engineering News*, 44(44): 20, Oct. 1966.

Plastic bottles: a search for stability. *Modern Packaging*, 40(10): 136–142, June 1967.

Plastic bottles fatten up on food sales. *Chemical Week*, 101(12): 57–60, Sept. 1967.

Plastic cans for motor oil. *National Petroleum News*, 58: 134–135, Sept. 1966.

The plastic milk bottle: time of decision. *Modern Packaging*, 38(7): 163–169, Mar. 1965.

Plastic resins for packaging films could nearly double in sales by 1975. *Oil, Paint and Drug Reporter*, 4, June 1965.

Plastics at the end of the decade. *Modern Plastics*, 44(8): 171–172, Apr. 1967.

Plastics catch on in crowns. *Chemical Week*, 96(7): 37–38, Feb. 1965.

Plastics help wrap up a holiday market. *Chemical Week*, 97(23): 20–21, Dec. 1965.

Plastics industry forecast for 1980: nearly eight times present size. *Oil, Paint and Drug Reporter*, 7, Feb. 1967.

The plastics industry in 1966: the facts and the figures. *Modern Plastics*, 44(5): 115–122, Jan. 1967.

The plastic market in packaging. *Modern Plastics*, 43(8): 193–195, Apr. 1966.

Plastics seen gaining for drugs packaging. *Oil, Paint and Drug Reporter*, 7, Nov. 1965.

Plastics usage in packaging, propelled by milk containers, seen doubling in five years. *Oil, Paint and Drug Reporter*, 3, Apr. 1965.

Polglase, T. R. Modern trends in wire packaging. *Wire and Wire Products*, 40(7): 971–974, 1020–1021, July 1965.

Pollard, T. "Quick" sell counts in packaging. *Kansas City Star*, Oct. 1967.

Polyethlene packaging: outlet in the deep freeze. *Oil, Paint and Drug Reporter*, 3, Apr. 1963.

Polyethylene, polypropylene set to invade oil can market. *Chemical and Engineering News*, 45(30): 13, July 1967.

Polypropylene—prices and markets. *Modern Plastics*, 44(9): 107–110, May 1967.

Polystyrene foam reaches for new markets. *Chemical and Engineering News*, 45(18): 32–33, Apr. 1967.

Potter, B. The bottle pack system. *Plastics*, 32(351): 71–72, Jan. 1967.

Prescott, J. H. Composting plant converts refuse into organic soil conditioner. *Chemical Engineering*, 232–234, Nov. 1967.

Proceedings of MECAR Symposium, Incineration of solid wastes, New York, Mar. 1967.

Proceedings, National Conference on Solid Waste Research, Chicago, Dec. 1963, University of Chicago Center for Continuing Education. Special Report No. 29. American Public Works Association, 1964. 228 p.

Process unit wins marketable goods from garbage. *Chemical Engineering*, 90–92, Apr. 1964.

Production briefs. *Business Week*, Nov. 1967.

Products & processes. *Fortune*, 199–200, Dec. 1964.

Profits in hot melts. *Modern Packaging*, 113–119, Sept. 1966.

A program for municipal refuse collection. Prepared by Department of Public Works, Kansas City, Missouri, Feb. 1966.

Progress in PE extrusion coating. *Modern Plastics*, 84–89, May 1963.

Pulp—perilous market for chemicals. *Chemical Week*, 57–71, Nov. 1966.

Putman Publishing Company. Recent trends in containers and packaging materials used for food and beverages. *Food Processing & Marketing*, Jan. 1967.

Putnam, R. A. Materials guide: paperboard for packaging. *Industrial Design*, 73–77, June 1967.

Putting sparkle into used drums. *Chemical Week*, 47–52, Aug. 1963.

QFF's annual packaging review. *Quick Frozen Foods*, 47–74, July 1966.

Question accuracy of APWA solid waste report. *Refuse Removal Journal*, 20–21, Oct. 1966.

Questions & answers. *Modern Packaging*, 138, Jan. 1967.

Quieting the clang and clatter. *Business Week*, 146–147, Dec. 1967.

Quillen, B. D. Low cost refuse burner eliminates dump. *Public Works*, 96–97, Mar. 1965.

Rx for hospital-drug safety. *Modern Packaging*, 104–108, Dec. 1967.

Rapid transfer system speeds refuse collection. *American City*, 46, Oct. 1966.

Realigning in resins. *Chemical Week*, 29, May 1962.

Reclamation and reuse of industrial waste. *Secondary Raw Materials*, 27, Nov. 1967.

Refuse processing twists promise doom for dumps. *Chemical Week*, 26–27, May 1964.

Refuse Removal Journal reports on the sanitation industry, 2.8 billion growth market. Conducted and tabulated by: Andrew H. Bates, Inc., Apr. 1964.

Refuse sacks are in. *American City*, 80(12): 96–97, Dec. 1965.

Rennicke, N. G. Corrugated box manufacture—its growth and prospects. *Paper Trade Journal*, 148(33): 32–35, Aug. 1964.

Research urged to strengthen scrap trade. *Iron Age*, 195(12): 109, Mar. 1965.

President's Science Advisory Committee, Environmental Pollution Panel. *Restoring the quality of our environment.* Washington, D.C., The White House, 1965. 317 p.

Rich, crunch goodness: $10 million a bowl. *Newsweek*, 70: 76, Nov. 1967.

Rich, L. Tempest in a milk carton. *Dun's Review and Modern Industry*, 86(6): 101–111, Dec. 1965.

Riley, N. Adhesive in packaging. *Soap and Chemical Specialties*, 40(12): 181–183, Dec. 1964.

Robinson, D. Burning curb seen as spurring debris-dumping in city waters. *The New York Times*, 38, May 1967.

Rogus, C. A. Collection and disposal of oversized burnable wastes. *Public Works*, 97(4): 106–110, Apr. 1966.

Rogus, C. A. European developments in refuse incineration. *Public Works*, 97(5): 113–117, May 1966.

Rogus, C. A. Refuse collection and refuse characteristics. *Public Works*, 97(3): 96–99, Mar. 1966.

Rohr, F. W. One way to control it—burn it. *Actual Specifying Engineer*, 18: 74–79, Nov. 1967.

Rosenthal, A. G. Aluminum broadens beachhead in can market. *Modern Metals*, 21(8): 24–25, Sept. 1965.

Rosenzweig, M. D. New copper technology is is winning the ore. *Chemical Engineering*, 74: 88–89, Dec. 1967.

Sanchagrin, T. Change without end in sight. *Printers' Ink*, 288: 179–180, May 1964.

Sanchagrin, T. Management takes control. *Printers' Ink*, 290: 13–18, June 1965.

Sanchagrin, T. New directions for packaging. *Printers' Ink*, 292: 15–23, June 1965.

Sanchagrin, T. Packaging in 1967: design and structure. *Printers' Ink*, 294: 9–21, Apr. 1967.

Sanford, C. F. Elmira to try composting. *American City*, 80(7): 93–94, July 1965.

Sanitary fill supermechanized. *American City*, 20, Dec. 1965.

The sanitary landfill. *Current Municipal Problems*, 107–112, Aug. 1965.

Santelli, T. R. What's new in packaging: metals, plastics, paper and glass. *Purchasing Magazine*, 104–105, June 1966.

Science's promise and peril: packaging. *News Front*, 53, Jan. 1967.

Scrap shredding offers contamination solution. *Steel*, 25, May 1966.

Scrap trading sluggish, but prices are holding. *Steel*, 88, May 1967.

Sebastian, F. The worldwide rush to incineration. *American City*, 40, Dec. 1967.

Self-supporting landfill helps attract industry. *Public Works*, 116, Mar. 1967.

Set-up industry far from fading. *Paperboard Packaging*, 110–111, Aug. 1964.

Shakeup due in container markets? *Chemical Week*, 32–33, Sept. 1966.

The shape of plastics in containerization—more; bigger and better. *Modern Plastics*, 45(4): 86–90, 156–157, Dec. 1967.

Sheldrick, M. G. Better use of wastes spurs commercial application of hot briquetting. *Chemical Engineering*, 140–142, Dec. 1967.

Sherman, J. V. Sophisticated scrap. *Barron's*, 3, Dec. 1967.

Sherwood, P. W. Paper coatings—a growing market for petrochemical resin materials. *World Petroleum*, 50–54, Jan. 1964.

Sherwood, P. W. Paper versus plastics in the U.S. packaging market. *British Plastics* 91–93, Feb. 1965.

Shilling, H. Paperstock section: confusing, satisfactory . . . *Paperboard Packaging*, 47–48, Aug. 1967.

Shredders are reshaping the scrap industry. *Steel*, 62–68, Dec. 1966.

Siegal, R. L. Paperboard vs. plastics: a positive view. *Paperboard Packaging*, 71–73, Oct. 1965.

Simmons, R. G. A big transfer trailer. *American City*, 108–109, Oct. 1966.

Sintered fly ash goes to market. *Electrical World*, 94–95, June 1965.

Slatin, B. Paper and paperboard in the western states. *Oregon Business Review*, Dec. 1966.

Slurry system disposes of fly ash. *Electrical World*, 67–69, Aug. 1966.

Snell, J. R. How much does composting cost per ton?: "on the basis of a dumping fee only." *Compost Science*, 8(1): 17–18, Spring-Summer 1967.

Snyder, R. E. 42nd annual financial survey of the rigid paper box industry. National Paper Box Manufacturers Association, 1966.

Solid waste disposal gets federal effort. *Chemical & Engineering News*, 44(51): 50–54, Dec. 1966.

Solid wastes and systems analysis. *American City*, 81(9): 26, Sept. 1966.

Solid wastes. *Environmental Science and Technology*, 1(3): 199–202, Mar. 1967.

Solid wastes in perspective. *Proceedings, symposium on research needs*. American Public Works Association, Research Foundation, Philadelphia, 1966.

Solid-Wastes Management; Proceedings, National Conference, Davis Campus, April 4–5, 1966, University of California. 214 p.

Solid wastes. *Proceedings, symposium*; *Kansas State Department of Health*, Lawrence, 1966.

Solid wastes—the job ahead. *APWA Reporter*, 33(8): 5–11, 25, Aug. 1966.

Southam, E. V., and R. Winter. Place and future of paper in flexible packaging from a converter's point of view. *Paper*

Trade Journal, 150(40): 47–49, Oct. 1966.

SPAULDING, C. A. Prepackaging of meats now a dynamic converting market. *Paper Trade Journal*, 148(40): 35–38, Oct. 1964.

SPAULDING, C. A. Revolution in prepackaging of fruits and vegetables. *Paper Trade Journal*, 149: 32–33, Mar. 1965.

STANFORD RESEARCH INSTITUTE. Chemical economics. *Newsletter*, Oct.–Nov. 1965.

STANFORD RESEARCH INSTITUTE. *Long range planning report—Report No. 59*, June 1960.

STANFORD RESEARCH INSTITUTE. Refuse disposal. *Long range planning service—Report No. 298*, Sept. 1966.

STANTON, T. Marketing miniatures; more products come in one-use packages. *Wall Street Journal*, Apr. 1966.

Steelmakers set sights on packaging market. *Steel*, 157(15): 49, Oct. 1965.

STERN, W. Opening up the packaging exposition. *Industrial Design*, 91–108, June 1965.

STOAKES, H. R. Rigid paper boxes—where are they going? *Paper Trade Journal*, 30–35, Oct. 1964.

STOVROFF, H. Paperstock section: a continuing struggle with supply readjustment. . . *Paperboard Packaging*, 48–55, Aug. 1967.

TAPPI Deinking Conference covered secondary fiber use for conservation, technological and economic reasons. *Fibre Market News*, 1, Oct. 1967.

Tele-Purchasing: major trend in retailing? *Forbes*, 55–69, Oct. 1967.

Tensile strength of glass covers broad range. *Chemical and Engineering News*, 94–96, Nov. 1964.

That's not junk; it's billions of dollars. *Forbes*, 51, Apr. 1967.

Thermoforming molds a new image. *Modern Packaging*, 120–125, Dec. 1967.

They see a market for all they can make. *Business Week*, 50–53, Aug. 1965.

A thorough look at composting. *American City*, 20, May 1966.

Three composting plants and an incinerator. *American City*, 20, Jan. 1966.

Throwaway containers get a lift from pop. *Business Week*, 70–71, Aug. 1966.

Time for can change? *Chemical Week*, 33, July 1964.

Tissue: 1967. *American Paper Industry*, 33–35, Dec. 1966.

TOENSMEIER, P. A. High viscosity hot melt coater enlarges markets for waxed folding cartons. *Paperboard Packaging* 50–54, Mar. 1965.

Torpedoing container costs, Navy style. *Modern Packaging*, 166–168, Sept. 1967.

Transparent trays make new bid for meat packaging. *Modern Packaging*, 178–180, Feb. 1966.

TRAUX, D. E. Advantages and limitations of hot melt adhesives. *Paperboard Packaging*, 47–50, Apr. 1965.

Tubes: aiming for bigger markets. *Modern Packaging*, 98–103, May 1967.

Turmoil in PE. *Modern Plastics*, 45(3): 84–89, 158–160, Nov. 1967.

Turning fly ash from onus to bonus. *Chemical Engineering*, 98–302, May 1967.

$20-million market seen for new bottle. *Printer's Ink*, 76, Jan. 1965.

A $2½ billion price tag on anti-pollution. *Compost Science*, 28–29, Spring-Summer 1967.

U.S. Depatment of Commerce, Bureau of the Census. Current industrial reports; glass containers, 1966.

U.S. Department of Commerce, Bureau of the Census. Current industrial reports; metal cans, summary for 1959, 1960 and 1961.

U.S. Department of Commerce, Bureau of the Census. Current industrial reports; steel shipping barrels, drums, and pails, summary for 1959, 1960, 1961, and 1965.

U.S. Department of Commerce, Business and Defense Services Administration. *Containers and Packaging*, Quarterly Industrial Reports, 17(4), Jan. 1965; 18(1), Apr. 1965; 18(3), Oct. 1965; 18(4), Jan. 1966; 19(1), Apr. 1966; 19(4), Jan. 1967; 20(1), Apr. 1967; 20(2), July 1967; 20(3), Oct. 1967.

U.S. Department of Commerce, Business and Defense Services Administration. *Pulp,* *Paper, and Board*. Quarterly Industrial Reports, 21(2), June 1965; 21(3), Sept. 1965; 21(4), Jan. 1966; 22(1), Apr. 1966; 22(2), July 1966; 22(3), Oct. 1966; 22(4), Jan. 1967; 23(1), Apr. 1967; 23(2), July 1967; 23(3), Oct. 1967.

U.S. Department of the Interior, Bureau of Mines. Automobile disposal, a national problem, case studies of factors that influence the accumulation of automobile scrap. Washington, U.S. Department of Interior, 1967. 569 p.

U.S. Economics Corporation, The Econometric Institute, Inc. *The Outlook for the Economy and Glass Containers*, Second Report, 30, May 1967.

USI launches lease plan to spur plastic milk bottle use. *Chemical and Engineering News*, 45(33): 13, Sept. 1967.

U.S. Steel 'launches' super-thin, thin tin. *Steel*, 154(16): 43–44, Apr. 1964.

Using waters to propel a rocket. *Compost Science*, 8(1): 32, Spring-Summer 1967.

VAN BOSKIRK, R. L. The plasticope. *Modern Plastics*, 44(9): 41–43, May 1967.

VAN DERVEER, P. D. Kraft men meet in Wisconsin to hear latest developments. *Paper Trade Journal*, 147(40): 46–47, Oct. 1963.

VEAL, P. L. Present and future of rigid PVC bottles. *British Plastics*, 38(5): 258–261, May 1965.

Volume feeding: hungry for cost-cutting ideas. *Modern Packaging*, 40(12): 103–106, Aug. 1967.

Voluntary refuse bag system works. *Public Management*, 47(1): 20, Jan. 1965.

Volunteers to tidy up a nation. *Supervisory Management*, 11(7): 24–26, July 1966.

War for the packaging dollar. *Dun's Review and Modern Industry*, 84(6): 90–91, Dec. 1964.

WARD, R. Achievement and promise in packaging. *Drug & Cosmetic Industry*, 95(5): 712–843, Nov. 1964.

WARE, JOEL, Jr. New problems for fibre boxes. *Paperboard Packaging*, 92–101, Aug. 1965.

Waste disposal at bargain basement cost. *Factory*, 142–143, Aug. 1962.

Wax pushes into new markets. *National Petroleum News*, 112, Jan. 1965.

Wax sales on upswing again. *Chemical Week*, 61–64, Oct. 1967.

WEAVER, L. The sanitary landfill. *American City*, Mar.–May 1956.

WEISGERBER, G. A. Wax treated corrugated boxes are finding growing use. *Paper Trade Journal*, 50–52, May 1965.

WEISSMAN, F. T. Aerosols . . . present and future. *Soap and Chemical Specialties*, 128–129, Oct. 1965.

WEISSMAN, F. T. What's ahead for aerosols? *Soap and Chemical Specialties*, 144–145, Nov. 1965.

What does packaging really cost? *Modern Packaging*, 90–93, May 1967.

What's happening to prices? *Modern Packaging*, 115, Dec. 1965.

What's happening with film? *Modern Packaging*, 86–91, Jan. 1967.

What next for plastics? *Modern Packaging*, 78, Nov. 1963.

What supermarkets? *Modern Packaging*, 36(5): 81–86, Jan. 1963.

When will PVC really arrive? here are portents and problems. *Modern Packaging*, 156, May 1965.

Where are containers heading? *Packaging Engineering*, 34–36, Apr. 1967.

Where are materials and containers heading? *Packaging Engineering*, 91–98, Apr. 1967.

Where we go after 200-million. *Business Week*, 96–100, Nov. 1967.

Who put the soup in milk cartons? *Printer's Ink*, 65, July 1967.

WICKER, W. J. A new look at refuse composting. *Public Works*, 131–132, Oct. 1964.

The widening, wondrous world of packaging. *Dun's Review and Modern Industry*, 85–134, Dec. 1965.

Will we bury ourselves in garbage? *Engineering News-Record*, 25–26, May 1966.

WILLATT, N. More throw-aways. *Barron's*, 11, Aug. 1966.

WILLATT, N. No young squirt. *Barron's*, 45:5, June 1965.

WILEY, J. S. A discussion of composting of refuse with sewage sludge. *In* American Public Works Association Yearbook.

214

Chicago, American Public Works Association, 1966. p. 198–201, 207–208.

Williams, E. R., and R. J. **Black**. *Refuse collection and disposal: an annotated bibliography, 1958–1959*. Public Health Service Publication No. 91. Washington, U.S. Government Printing Office, 1961. 73 p. Suppl. D.

Williams, L. E. The changing role of the paper stock industry. *Secondary Raw Materials*, 48–51, Nov. 1967.

Wolf, H. P. Packaging. *Industrial Design*, 87–99, Sept. 1966.

Woodpulp section. *Paperboard Packaging*, 52(8): 39–46, Aug. 1967.

XT Polymer—new material of design. *Modern Plastics*, 43(6):82–171, Feb. 1966.

A year of realization. *Modern Packaging*, 38(7): 131–143, Mar. 1965.

Zapf, F., and H. Giles. Mammoth trucks and mini scooters. *American City*, 82(1): 77–79, Jan. 1967.

Zapp, G. M. New machine developments for modified wax paperboard coatings. *Paper Trade Journal*, 148(32):20–23, Aug. 1964.

Zeidman, R. H. Who's boss—marketing or production? *Modern Packaging*, 41(3): 124–128, Nov. 1967.

U.S. GOVERNMENT PRINTING OFFICE: 1969 O-336-369